The Influence of Selective Withdrawal Operation at Hungry Horse Dam on the Benthos and Water Temperature of the South Fork Flathead and Main Stem Flathead Rivers

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For
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EXECUTIVE SUMMARY

This aquatic invertebrate study began in September 1997, funded by Bonneville Power Administration (BPA), to assess the selective withdrawal device on Hungry Horse Dam, which allows operators to control water temperature in the Flathead River downstream. This study examined macroinvertebrate community composition, species diversity and seston in the South Fork of the Flathead River downstream from Hungry Horse Dam (regulated) and in the main stem Flathead River above (unregulated) and below (partially regulated) the South Fork confluence. Biological and physical parameters, river discharge and temperature observed during selective withdrawal operation were compared to similar data compiled prior to selective withdrawal by Hauer, Gangemi, and Stanford (1994) and Perry (1984).

Hungry Horse Dam has operated on a predictable annual cycle since the dam was installed on the South Fork Flathead River in 1952. Dam regulation essentially reversed the natural hydrograph, with high flows during winter for electrical generation and reduced discharges during spring runoff for flood control. Prior to the installation of selective withdrawal in 1995, water was discharged from the deep reservoir hypolimnion into the South Fork of Flathead River at about 4° C all year. Selective withdrawal now provides natural water temperatures during summer. Hypolimnetic releases from Hungry Horse Dam still alter the natural temperatures in the South Fork and main stem Flathead River from late October through June when selective withdrawal is not operational. Consequently, from mid-March through the end of June (when selective withdrawal begins) the natural, unregulated temperature regime of the North and Middle Forks is warmer than Hungry Horse Dam's hypolimnetic discharge. Selective withdrawal begins in June after spring runoff peaks and flows begin to reduce. The natural thermal regime is maintained until sometime in October when the reservoir approaches isothermal conditions at roughly 7-8° C. Greatest thermal influence occurred during the summer months, the critical period of insect and fish growth.

Water temperatures in the South Fork accumulated an average increase of 860 degree-days annually since selective withdrawal was installed. Water temperatures at the partially regulated site (Columbia Falls) increased by an average of 340 degree-days each year since thermal control was implemented. Since 2001, flow fluctuations have occurred at a gradual ramping rate and the minimum flow in the South Fork changed from 145 cfs to 400-900 cfs, a sliding scale based on water supply (Marotz and Muhlfeld 2000).

Results from seston sampling were limited (due to a lab malfunction), but showed a general increasing trend of large (> 500um) particulate organic matter (POM) from upstream to downstream. Both the available sampling dates contained lower POM values compared with those reported by Hauer et al. (1994).

Ephemeroptera, Plecoptera, Trichoptera, and Diptera dominated the aquatic insect community at each sample site. Micro-picked samples were not analyzed.

Therefore, the Chironomids and Oligochaetes were not identified or enumerated. This minimizes the calculated densities of taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera. By not enumerating the more numerous and smallest instars of these orders this study underestimates the abundance of all taxa. Density comparisons between species found in this and previous studies as a measurement of selective withdrawal's effectiveness would be invalid.

The two most commonly occurring Ephemerellid genera were *Drunella* and *Ephemerella*. *Ephemerella* spp. was the most abundant mayfly present during the study period. The highest mean annual density occurred in the South Fork below the dam (Site one). Unlike *Ephemerella* spp., *Drunella* spp. was completely absent from the South Fork below the dam. The highest mean annual densities occurred at Site two, the unregulated portion of the Flathead River. *Baetis*, a very common genus in riverine environments, had the second highest mean annual density in this study. The highest mean annual density was found in the South Fork below the dam (Site one). The family Heptageniidae was also relatively abundant in this study, with the genus *Rhithrogena* comprising the largest component. Heptageniid highest mean annual densities occurred at Site two, the unregulated portion of the Flathead River. *Leptophlebia*, a common genus in the North and Middle Forks and main stem river was absent at all the sites during this study.

Most stonefly species were either completely eliminated or very rare at Site one. The following were sampled in the South Fork below the dam: Nemourid *Zapata* spp., Taeniopterygid *Taenionema* spp., Perlodid *Isoperla* spp., and the Capniid nymphs. *Taenionema* was by far the most abundant stonefly genus sampled in this study. Abundances were greatest at the partially regulated Sites of four, three and five respectively. The Capniidae were the second most common stonefly family and were observed in greatest abundance at the partially regulated Site four. *Isoperla* spp. was most abundant in the spring samples. Abundance achieved maximum values at the partially regulated Site three. The family, Perlodidae, to which the genus *Isoperla* belongs, correspond to the third most abundant stonefly mean annual densities in the study. Chloroperlids closely followed this group in abundance with Perlid nymphs comprising substantially the lowest densities.

The net-spinning caddisflies were the most abundant of the Trichoptera collected in this study. Members of the family *Hydropsychiidae* occur abundantly in the unregulated and partially regulated waters of the Flathead River. Highest mean annual densities of the genus *Hydropsyche* were found at the partially regulated Site three with declining but still high densities at the unregulated Site two and Site four, respectively. The genus *Arctopsyche* exhibited a different response in larval densities. Similar to *Hydropsyche* species, the highest mean annual density of *Arctopsyche* was exhibited at the partially regulated Site three. Mean annual densities decreased from there to Sites four and one (regulated site), respectively. Site two (unregulated site) and Site five (Old Steel Bridge) had the lowest observed densities of *Arctopsyche*. We observed densities of

Hydropsyche spp. to be higher than *Arctopsyche* spp. at all five sampling sites, especially at partially regulated Sites three and four.

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ACKNOWLEDGEMENTS

This work represents the most recent in a series of efforts assessing how switching from hypolimnetic releases to selective withdrawal operation at Hungry Horse Dam altered certain physical parameters and portions of the aquatic biota in the Flathead River downstream. Precursors to this work include an examination of aquatic community composition and a description of physical parameters prior to retrofit by researchers at the University of Montana Biological Station (UMBS) and Sue Perry at North Texas State University. I extend my thanks to the following individuals and agencies that provided valuable assistance, either directly or indirectly during the course of this study. The Bureau of Reclamation at Hungry Horse Dam through the cooperation of superintendent Ralph Carter provided needed discharge releases during sampling periods. John Gangemi provided his technical experience and historical background by showing us the sampling sites, field methodology, and equipment nuances from the study. We designed this study following work by Hauer, F.R., J.T. Gangemi, and J.A. Stanford (1994). Joe Giersch provided an aquatic entomology tutorial course prior to the identification phase of this project. Flathead Valley Community College (FVCC) in Kalispell, Montana through the cooperation of Chemistry Professor Paul Martino provided lab space and equipment to process seston samples. Gary Michael provided much needed assistance conducting the field sampling. Gary also identified all Trichopterans sampled while Tom Weaver identified all Ephemeropterans. I would like to thank Rick Hauer of UMBS for taking time to answer the various questions I had concerning seston lab methodology and for confirming insect identification of our sample library. I appreciate the time and mental energy given by John Gangemi, Tom Weaver, Mark Deleray, and Brian Marotz for making editorial comments. Christine Caye compiled numerous manuscript drafts and completed word processing, including the final manuscript. Bonneville Power Administration (BPA) provided funding for this project. Finally, I would like to thank project biologist Ladd Knotek and project manager Brian Marotz for providing direction and showing much patience while this study was completed over a lengthy period of time.

INTRODUCTION

The U.S. Bureau of Reclamation (Bureau) completed Hungry Horse Dam in 1952, impounding the South Fork of the Flathead River. The dam was designed with four turbine penstocks located 73 m (241 feet) below full pool elevation (3560 ft msl). Water discharged from this depth into the South Fork is fairly constant at about 4° C (39 to 41° F) year round. Thermal changes and flow regulation have significantly altered the invertebrate fauna and fisheries dynamics in the 8 km (5 miles) of the South Fork downstream of the dam. Altered flows and water temperatures also effect the main stem Flathead River from the South Fork confluence, downstream for more than 64 km (40 miles) to Flathead Lake (Marotz, Althen, and Gustafson 1994).

Sudden increases in discharge volume translate into very rapid thermal depressions. This is especially apparent when flows from the North and Middle forks decline to basal conditions after spring runoff. Instantaneous thermal fluctuations up to 8.3° C (15° F) were common prior to selective withdrawal, associated with intermittent flow releases for power generation. Unnatural thermal fluctuations were detectable in the Flathead River downstream to Flathead Lake. Hypolimnetic releases grossly reduced the annual accumulation of degree-days during summer and artificially elevated temperatures during winter (Marotz et al. 1994). These rapid thermal spikes are seasonally typified by summer cooling and winter warming and have been linked to biological changes in the Flathead River Basin (Hauer et al. 1994).

In an attempt to remedy the thermal problem in the South Fork and main stem Flathead River, a multi-level outlet system (called selective withdrawal) was proposed for further study in 1976 by the Pacific Northwest River Basin Commission. Researchers from Montana Fish, Wildlife & Parks (MFWP) and the Bureau of Reclamation assessed the feasibility of releasing water from selected layers in the reservoir to mimic natural river temperatures downstream. Fraley and Graham (1982) estimated that trout growth in the South Fork could be increased by a factor of ten with the addition of selective withdrawal. They also noted that trout growth in the main stem Flathead River could be almost doubled. Despite these findings, no further actions were taken after resource managers predicted that warm water withdrawals would negatively impact fish populations in Hungry Horse Reservoir.

Selective withdrawal was reassessed beginning in 1990. In November 1991, the Northwest Power Planning council amended the Columbia Basin Fish and Wildlife Program of 1987. One of the program amendments, measure 903(h)(6), directed Bonneville Power Administration (BPA) and the Bureau to "…immediately begin actions to result in installation of a selective withdrawal structure at Hungry Horse Dam to allow for temperature control to benefit resident fish". As an interim measure, the Bureau instituted limits on discharge change rates in an attempt to moderate instantaneous temperature spikes. A computer model to simulate selective withdrawal was appended to the quantitative biological model of Hungry

Horse Reservoir (HRMOD) developed by MFWP and Montana State University (Marotz, Althen, Lonon, and Gustafson 1996). Simulation of the daily changes in reservoir hydrology, thermal profile and discharge depth provided accurate estimates of the effects of differing operational strategies on downstream water temperatures. Biological measures in HRMOD allowed researchers to assess benefits or trade offs upstream and downstream of the dam (Marotz et al. 1994). After examining several alternative methods for mitigating thermal pollution, it was determined that installation of selective withdrawal devices on all four penstocks was the most effective alternative to achieve permanent and constant control of discharge temperatures. Selective withdrawal devices were installed in 1995 and operated for the first season in 1996 (Christenson, Sund, and Marotz 1996).

This aquatic invertebrate study began in September 1997, funded by BPA, to assess the impacts of selective withdrawal operation on the benthos and water temperature in the Flathead River. The study examined macroinvertebrate community composition and species diversity in the South Fork of the Flathead River and in the main stem Flathead River above and below the South Fork confluence.

STUDY AREA

The Flathead River drains 22,241 km^2 of the Rocky Mountains west of the Continental Divide in British Columbia and Montana and has an average annual discharge of 330 cms (11,760 cfs) (Hauer et al. 1994). The Flathead River consists of three forks: the North Fork, Middle Fork and the South Fork of the Flathead River (Figure 1). Hungry Horse Dam impounds the South Fork of the Flathead River. At full pool (1085.8 m or 3560 ft msl), the reservoir is 56 km in length with an area of 96.3 km^2 and an operational volume of 4.24 km^3 (3,468,000 acre-ft) (Cavigli, Knotek, and Marotz 1998). Immediately downstream of the South Fork confluence, the main stem Flathead River flows through a short, narrow canyon and then for 64 km across the Flathead Valley through terrain of relatively low slope to Flathead Lake. This portion of the river meanders through the broad alluvial valley with braided, shallow channels and wide riffles until it reaches the section influenced by the lake (Perry, Perry, and Stanford 1987).

OPERATION OF SELECTIVE WITHDRAWAL

Selective withdrawal operates on each penstock using a gate system that resembles a three-section telescope cut in half lengthwise. The selective withdrawal structures are 72.3 m long when fully extended and average 6.25 m in diameter (Figure 2). The top section, called the control gate, can move up and down over a 37 m distance. The control gates slide against the middle stationary gates. Lowering the control gate allows warm surface water to flow into the device and through the dam. The control gate cannot be stationed closer than 6.1 m from the surface to avoid hydraulic cavitation. Five side-by-side slide gates located 15.2 m below the top of each control gate allow operators to mix in cold water. Slide gates were designed to simultaneously release warm and cool layers

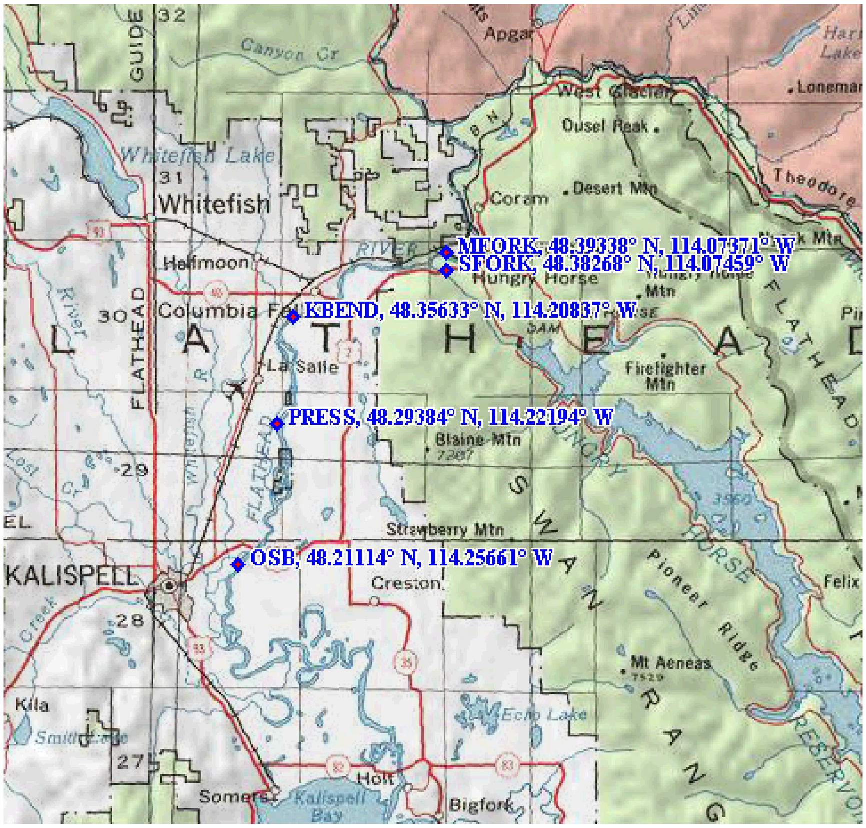


Figure 1. Sampling site locations in the study area during 1997 and 1998

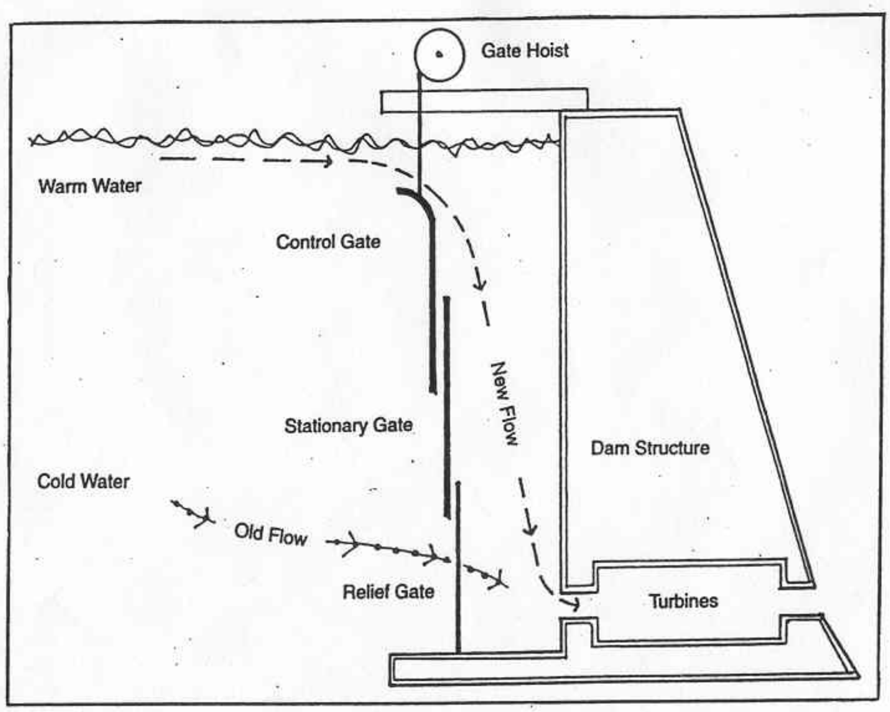


Figure 2. Selective withdrawal structure at Hungry Horse Dam.

of the reservoir to achieve an intermediate target temperature in the tailwater while reducing entrainment (downstream loss) of zooplankton (Cavigli et al. 1998). The bottom section, the relief gate, rests on the concrete apron at the bottom of the trash-rack. In winter, the relief gates are raised and water passes through the original penstock openings to release hypolimnetic water.

Selective withdrawal was tested for only one and a half months (mid-August through September) in 1995. Since 1996, the device has operated annually beginning in June or early July, when natural river temperatures can be achieved, through October each year.

METHODS

RIVER FLOW AND TEMPERATURE

River discharge data were obtained from the USGS for the South Fork and main stem Flathead River at Columbia Falls (USGS sites 12362500 and 12363000, respectively). Temperature data were obtained from the USGS for the North Fork near Columbia Falls, South Fork below Hungry Horse Dam and main stem Flathead River at Columbia Falls (sites 12355500, 12362500, 12363000, respectively) as well as from MFWP on the Middle Fork near Hungry Horse. Temperature and flow data are expressed as daily means.

INVERTEBRATES

This study was patterned after Hauer et al. (1994). We sampled the same riffle sites and followed a similar sample schedule throughout the annual cycle, using the same sampling methods and equipment. The Bureau provided specific discharge volumes from Hungry Horse Dam to assure the riffle areas sampled had remained inundated for a minimum of 30 days on all sampling dates.

Five sampling sites were located along the longitudinal gradient of the river system (Figure 1). Sampling site one (Sfork) was located on the regulated South Fork of the Flathead River below Hungry Horse Dam approximately 0.3 km upstream of the Hwy. 2 bridge. Site two (Mfork) was situated on the unregulated portion of the Flathead River approximately 1.7 km above the confluence of the South Fork. Sampling site three (Kbend) was located approximately 12 km below the confluence of the South Fork at Kokanee Bend fishing access site. Site four (Press) was situated approximately 30 km below the confluence with the South Fork at Pressentine Bar fishing access site. Site five (Osb) was located approximately 50 km below the confluence of the South Fork at the Old Steele Bridge in Kalispell (Kiwanis Lane fishing access). Sites three, four, and five are considered partially regulated sites on the main stem Flathead River because regulated flows from Hungry Horse Dam on the South Fork of the Flathead are mixed with natural flows from the North and Middle Forks.

The five sites were sampled six times throughout the annual cycle, beginning September 1997 through August 1998. At each site benthic invertebrates were sampled in riffle areas using a modified kick-net technique developed by Hauer (1980) and used by Perry (1984). Three replicate 0.25 m^2 plots were sampled at each site, randomly moving upstream after each sample was taken. Surface stones from within the framed area were hand washed in front of the net and set aside. Stepping into the framed area and kicking vigorously back and forth physically disturbed the sample region, allowing dislodged organisms to wash into the net. Total time to complete both applications was about one minute. The dimensions of the modified sampling kick-net include two wooden 1.2 m dowels, which support the 1 x 1 m square, 243 um mesh Nitex net. A 1.2 m conical shaped net made of 118 um mesh Nitex is sewn in at the square's center with a 36 x 36 cm opening. The conical net's cod end finishes with a 7.6 x 23 cm Plexiglas bucket. Samples were field preserved in 95% Ethanol. At a later date, samples were rinsed in the lab, one at a time onto a round 125 um mesh sieve (20.3 cm diameter) and shaped into a circle. The circle was fractioned into measurable pie segments and invertebrates were picked and sorted by size into their respective orders. The sub-samples were divided into three groups: the gross, sub-sample, and micro pick. The 'gross pick' included the largest organisms that made the fractioned sample heterogeneous by size of invertebrates. After picking these organisms out, the resulting homogeneous fractioned sample was rinsed into a tray to float the organisms. A magnifying glass aided in picking and sorting the remaining invertebrates into their respective orders, targeting a total of 100-400 organisms per fractioned sample. Mean numbers per square meter were calculated for individual taxa by sampling date for each sample site. These six means were summed and their average was calculated for each species at each sampling site and referred to as the annual mean. The smallest organisms left over comprised the 'micro pick'. Examination of organisms was made using a dissecting scope at 6x to 50x magnification. Taxonomic keys by Merrit and Cummins (1984), Stewart and Stark (1988), Edmunds, Jensen, and Berner (1976), and Wiggins (1977) were used for identification.

SESTON

Particulate organic matter was sampled simultaneously with the invertebrate sampling at each of the sampling stations. Three drift nets with an 820 cm^2 opening and a net mesh size of 500 um Nitex were placed perpendicular to river flow in current velocities of 0.3-0.9 m/sec and allowed to fish for 30 to 40 minutes. Current velocity was measured directly in front of each submerged drift net (Hauer et al. 1994). The total volume of water sampled by each net was calculated as
CV x A x T = V

Where CV = current velocity
A = area of the drift net opening
T = total time the drift net fished
V = total volume of water sampled

The seston collected by each drift net was field preserved in 95% Ethanol in separate containers and returned to the lab. Samples were transported to FVCC

chemistry lab. Whatman GF/C glass-fibre filters (45 um pore size) were placed in a drying oven set at 100°C for at least one hour. Filters were weighed ($\pm$ 0.1 mg) on a Mettler analytical balance after cooling in open air for ten minutes. A vacuum filtration system was set up using a rotary 2 cfm Vine vacuum pump. Samples were individually rinsed with distilled water into a filter cup containing the pre-weighed filter paper and allowed to filter for five minutes. Each filtered sample was removed, placed on foil and set in a drying oven overnight. After removal and cooling for ten minutes, each filter and its associated material were weighed ($\pm$ 0.1 mg) and recorded. The weighed filters were then fit into a foil envelope (dull side faced toward sample) and placed into a Muffle furnace set at 500° C overnight. The resulting ash sample and filter were removed from the furnace and rehydrated with distilled water, then placed in a drying oven set at 100°C overnight. Again, after removal and cooling for ten minutes, each filter and its associated ash sample was weighed ($\pm$ 0.1 mg) and recorded.

RESULTS

FLOW AND TEMPERATURE

River discharge out of the South Fork Flathead River for water years (WY) 1997 & 1998 followed a similar pattern, although peaks in discharge were generally higher in WY 1997 (Figure 3). Beginning sometime around December 1st of 1996 Hungry Horse Dam began releasing mean daily discharge of 6000 to 9000 cfs. This continued into late April. Then, daily discharges dropped off to less than 3000 cfs until the first week of June. During the month of June mean daily discharge fluctuated dramatically from minimum flows up to 13000 cfs. July 1 to early August discharge was erratic, ranging from minimum flows to 5000 cfs. From there to September 1 mean daily discharge was higher and ranged from 8000-11000 cfs. Discharge cycled on a weekly basis between 2300 and 5000 cfs for the remainder of the WY. In comparison WY 1998 showed an increase in mean daily discharge (2500-7000 cfs) around mid-November and lasted until late March, and then dropped off to minimum flows (250 cfs) until mid-May. During spring runoff, mean daily discharge fluctuated dramatically on a daily basis from minimum flows up to 7000 cfs. Mean daily discharge for the period, July 1 to mid-August was consistent, running near 7000 cfs while mid-August to September 1 discharge gradually decreased to 2000 cfs. The rest of WY 1998 saw a consistent 1900 to 2500 cfs mean daily discharge out of Hungry Horse Dam (Figure 4).

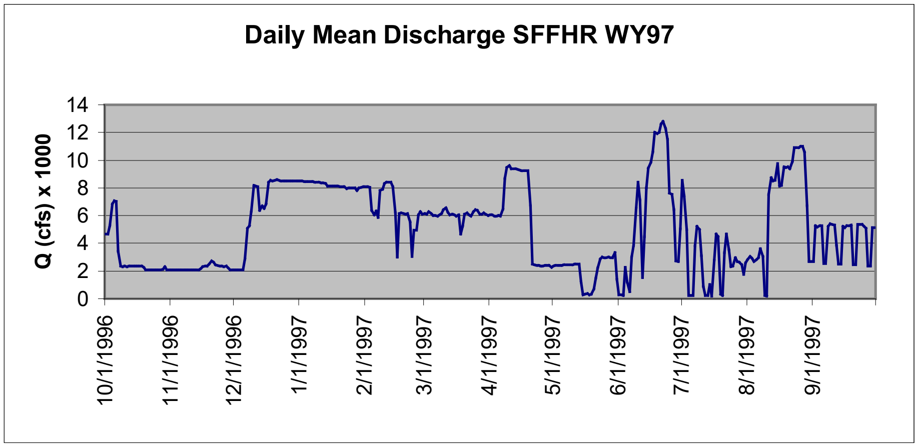


Figure 3. River discharge (cubic feet per second) in the South Fork Flathead River below Hungry Horse Dam for water year 1997.

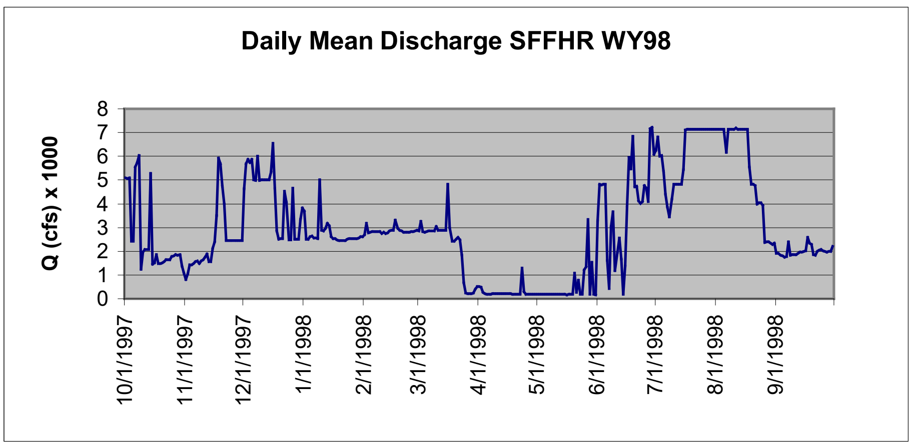


Figure 4. River discharge (cubic feet per second) in the South Fork Flathead River below Hungry Horse Dam for water year 1998.

Fluctuating daily or monthly discharges still occur out of Hungry Horse Dam. But during the months that selective withdrawal was in operation these discharges were no longer coupled with a marked decrease in stream temperature downstream in the main stem Flathead River. Natural temperatures from the North and Middle Forks for water years 1997 and 1998 were closely matched in the partially regulated main stem at Columbia Falls from October 1st to early November, and early March through September (Figures 5 & 6). The natural, unregulated mean daily temperatures consistently varied from those at the partially regulated site of Columbia Falls during the winter months (mid November through February). This was due to the release of warmer hypolimnetic reservoir water through that time period. In July and August, there were smaller differences between the unregulated North and Middle Fork natural mean daily temperatures and the temperature of selective withdrawal released water. Selective withdrawal releases are based on seasonal averages that could differ slightly from ambient temperatures exhibited in the North and Middle Forks.

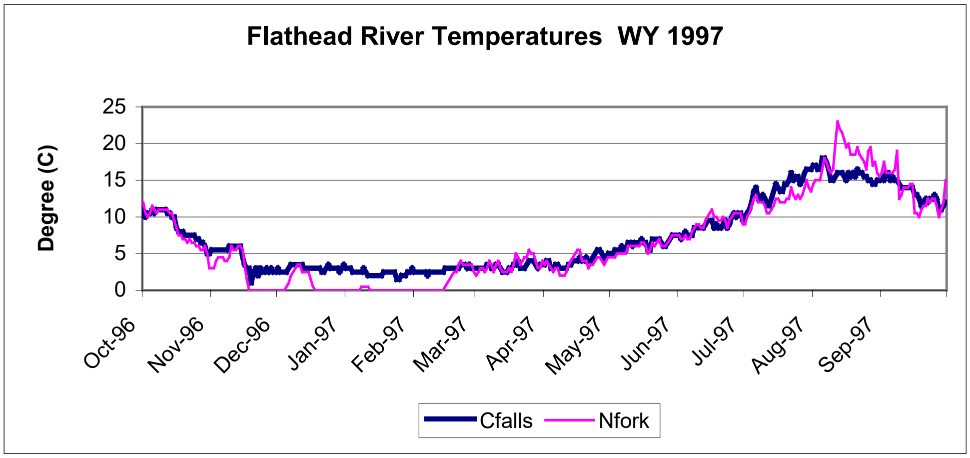


Figure 5. Mean daily temperatures in degrees Celsius at the Columbia Falls (partially regulated Flathead River) and the North Fork Flathead River (Unregulated) thermograph sites in water year 1997.

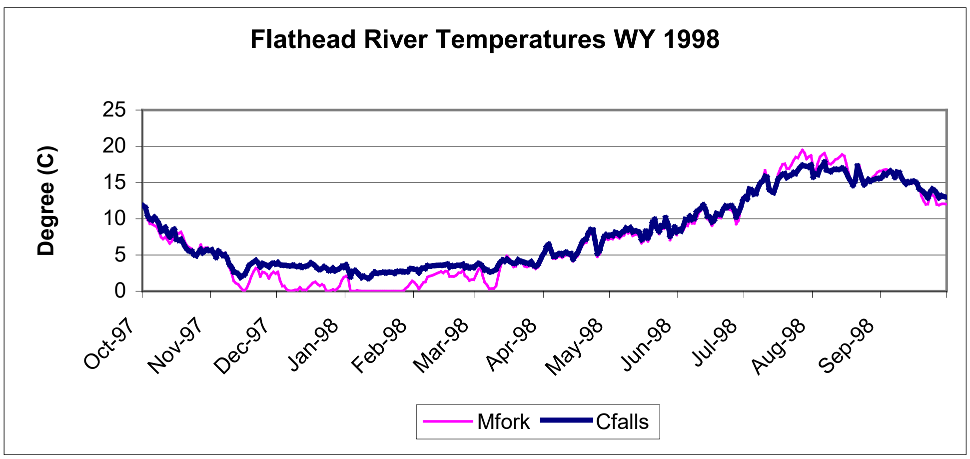


Figure 6. Mean daily temperatures in degrees Celsius at the Columbia Falls (partially regulated Flathead River) and the Middle Fork Flathead River (Unregulated) thermograph sites in water year 1998.

SESTON

Only two of the six sample dates have seston information concurrent with macroinvertebrate data. Nearly halfway through processing the seston samples, the Muffle furnace at FVCC, used to burn the samples to ash, malfunctioned. Unpredicted temperature spikes amalgamated the glass filters and resulting ash into indistinguishable masses that could not be processed further. The problem continued and was not remedied. Therefore the September and October samples of 1997 were the only ones left intact. These samples showed a general trend of increasing large particulate organic matter (> 500um) (POM) from upstream to downstream (Appendix A). Site one, the South Fork below Hungry Horse Dam had the highest value of the September samples while the October value for Site one was similar to Site two, the unregulated Flathead. Site five the lowest site on the

partially regulated Flathead had a disproportionately high value compared with the other sites during October. Both sampling dates contained lower POM values compared with those reported by Hauer et al. (1994).

INVERTEBRATES

The Ephemeroptera, Plecoptera, Trichoptera, and Diptera dominated the aquatic insect community at each sample site. Lab personnel identified 41 taxa in collections at the five sampling stations (Table 1). Mean densities for each taxa were highly variable temporally and by sampling site (Appendix B). Micro-picked samples were not analyzed therefore the Chironomids and Oligochaetes were not identified or enumerated. This fact also affected the calculated densities of taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera. By not enumerating the more numerous and smallest instars of these orders this study has underestimated the abundance of all taxa. Therefore, no density comparisons were made between species found in this and previous studies as a measurement of selective withdrawals effectiveness.

Table 1. List of taxa collected from the main stem and South Fork of the Flathead River between September 1997 and August 1998.

<u>Ephemeroptera</u>

- Siphlonuridae
  - *Ameletus spp.*
- Ephemerellidae
  - *Caudatella spp.*
  - *Drunella doddsi*
  - *Ephemerella spp.*
  - *Ephemerella grandis*
  - *Timpanoga spp.*
- Baetidae
  - *Baetis spp.*
- Heptageniidae
  - *Cinygma spp.*
  - *Cinygmula spp.*
  - *Epeorus spp.*
  - *Rhithrogena spp.*
- Leptophlebiidae
  - *Paraleptophlebia spp.*

<u>Trichoptera</u>

- Hydropsychidae
  - *Arctopsyche spp.*
  - *Hydropsyche spp.*
- Brachycentridae
  - *Brachycentrus spp.*
- Glossosomatidae
  - *Glossosoma spp.*
- Hydroptilidae
  - *Hydroptila spp.*
- Rhyacophilidae
  - *Rhyacophila spp.*

<u>Coleoptera</u>

- Elmidae

<u>Oligochaeta</u>

<u>Plecoptera</u>

- Perlidae
  - *Claassenia spp.*
  - *Doroneuria spp.*
  - *Hesperoperla spp.*
  - *Perlidae spp.*
  - *Calineuria spp.*
- Pteronarcyidae
  - *Pteronarcella spp.*
  - *Pteronarcys spp.*
- Taeniopterygidae
  - *Taenionema pacificum*
- Nemouridae

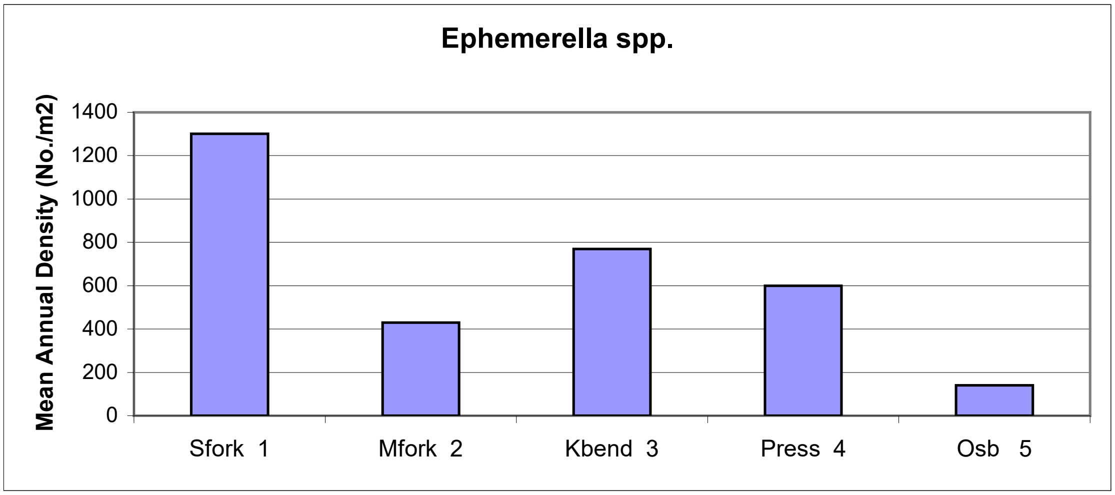
Table 1 (Con't)

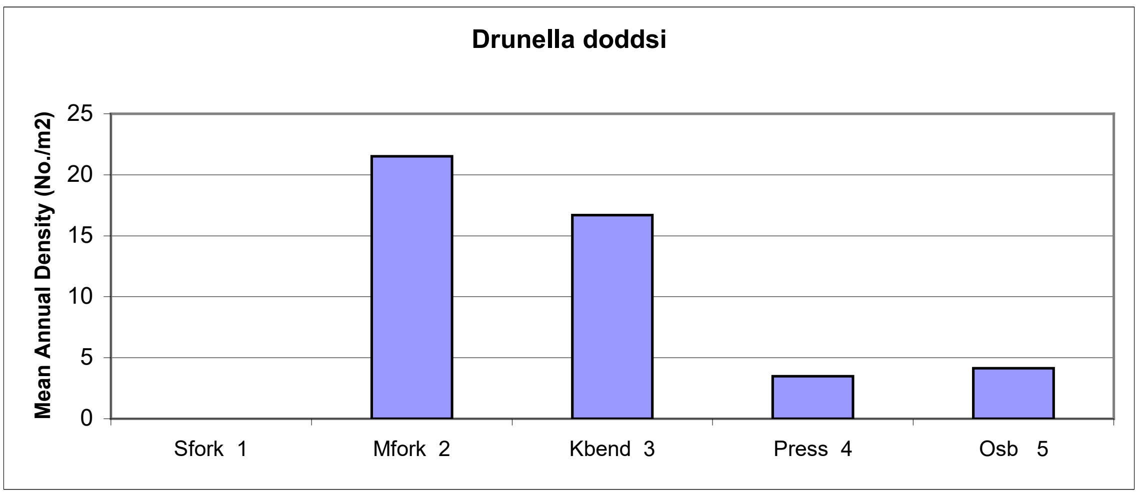
Capniidae	*Prostoia spp.*
Chloroperlidae	*Zapada spp.*
Paraperla spp.	
Suwallia spp.	
Sweltsa spp.	
Perlodidae	Diptera
Cultus spp.	Chironomidae
Diura spp.	Simuliidae
Isogenoides spp.	Tipulidae
Isoperla spp.	
Skwala spp.	n=41 taxa

Ephemeroptera

The two most commonly occurring Ephemerellid genera were *Drunella* and *Ephemerella*. *Ephemerella* spp. was the most abundant mayfly present during the study period. The highest mean annual density (Figure 7) occurred in the South Fork below the dam (Site one). Densities decreased at Site three, four and two, respectively, while Site five had by far the lowest densities. Maximum densities (Figure 8) were found in the April sample (~ 6000 individuals/m^2) and dropped off significantly in the August and September samples. Unlike *Ephemerella* spp., *Drunella* spp. was completely absent from the South Fork below the dam. The highest mean annual densities (Figure 7) occurred at Site two, the unregulated portion of the Flathead River, followed closely by Site three, and with even lower densities by Sites five and four, respectively. Maximum densities were found in the September through November samples (Figure 8).

Baetis, a very common genus in riverine environments, achieved the second highest total mean annual density in this study. The highest mean annual density (Figure 7) was found in the South Fork below the dam (Site one) with their highest numbers occurring in the April sample (~ 4900 individuals/m^2). The lowest density found in the South Fork was the March sample. The unregulated Site two achieved the second highest mean annual density and decreased progressively from there at Sites three through five. The highest density (Figure 8) of *Baetis* at Site two was sampled in March (<1100 individuals/m^2).





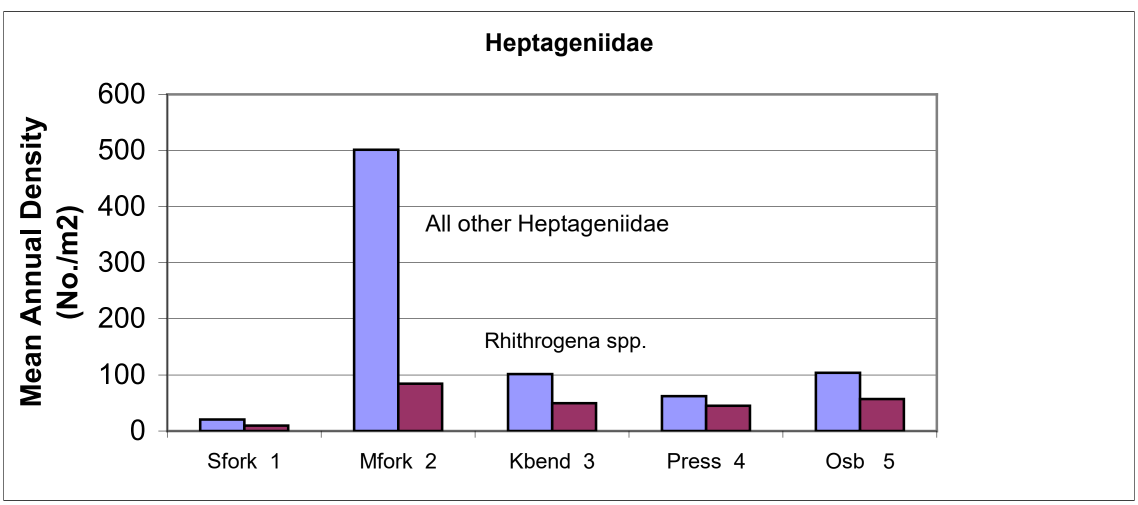


Figure 7. Mean annual density (#/m^2) of abundant mayflies at each of the five sampling sites on the South Fork and main stem Flathead River. **(CONTINUED NEXT PAGE)**

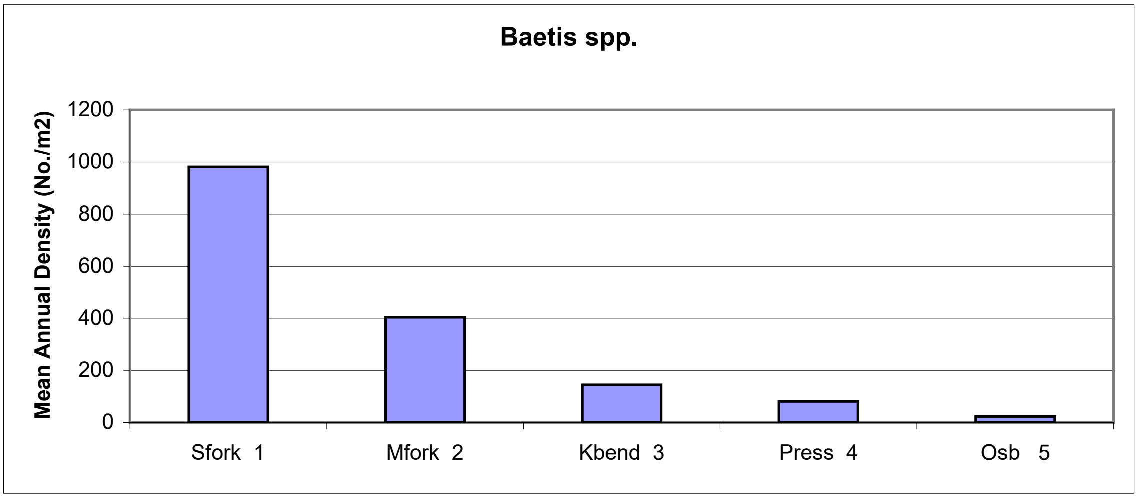
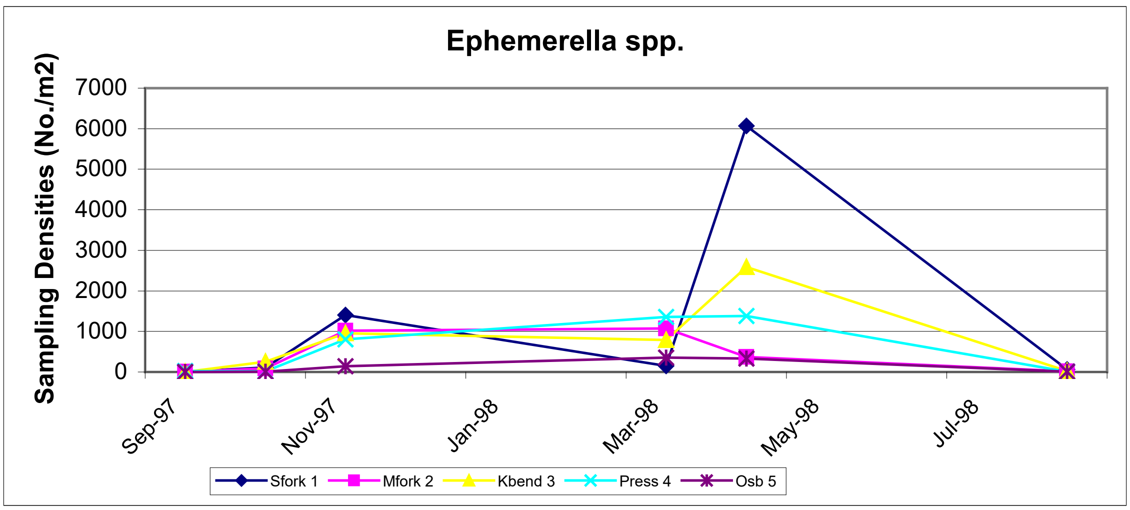


Figure 7. (Con't) Mean annual density (#/m^2) of abundant mayflies at each of the five sampling sites on the South Fork and main stem Flathead River.



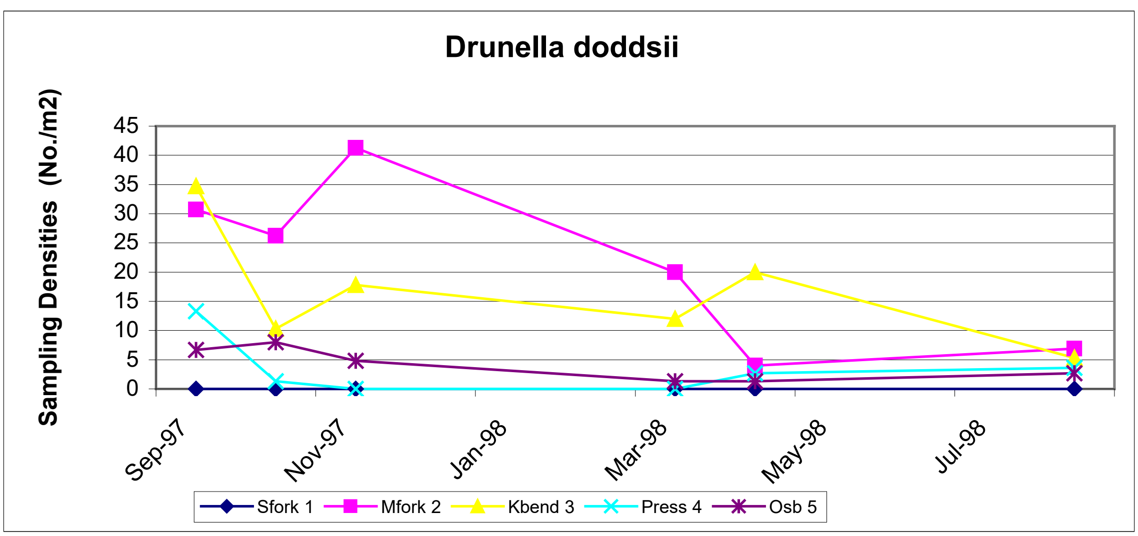
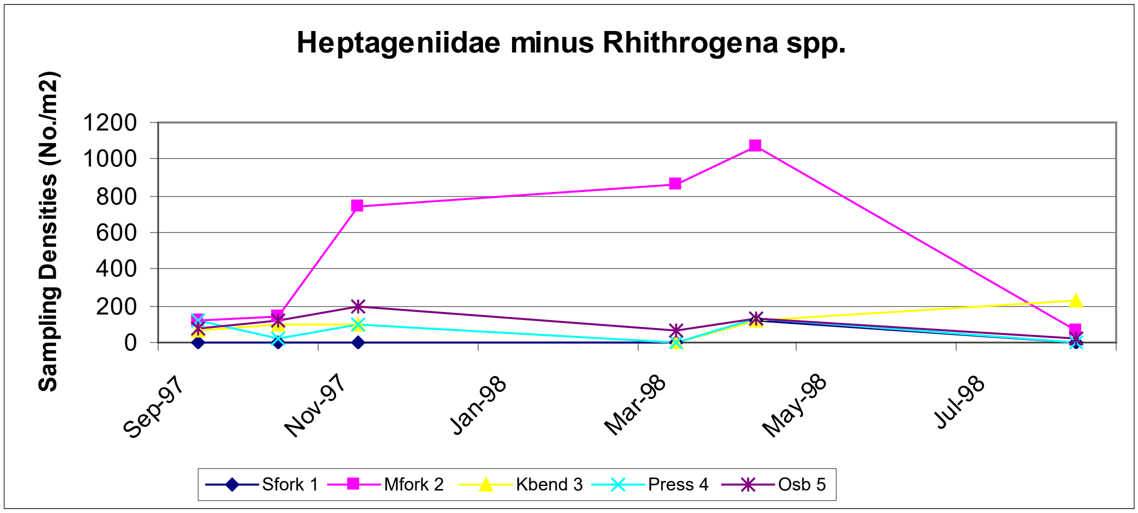
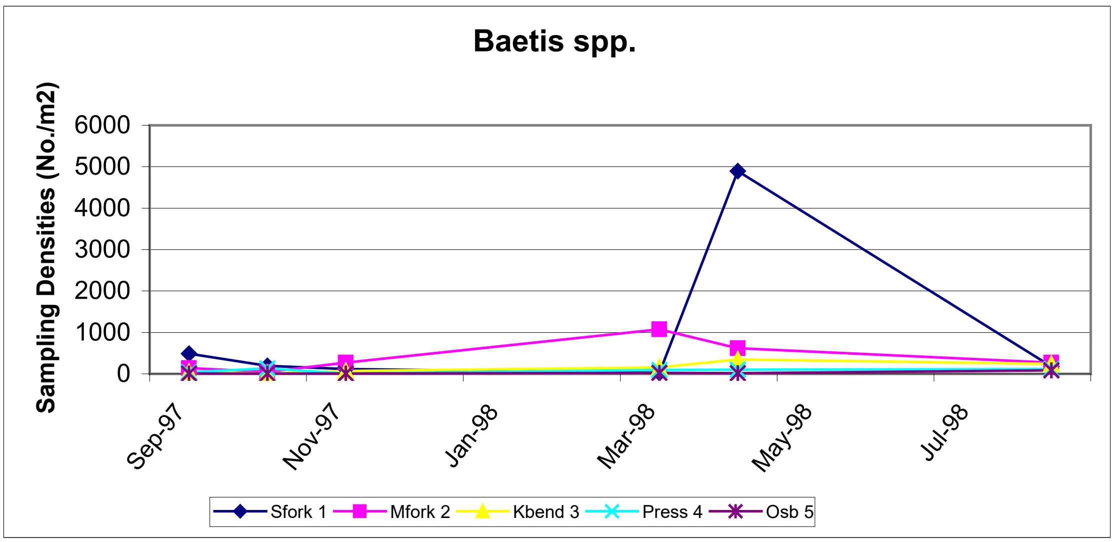


Figure 8. Variability in mayfly densities (#/m^2) by site through the annual cycle. **(CONTINUED NEXT PAGE)**





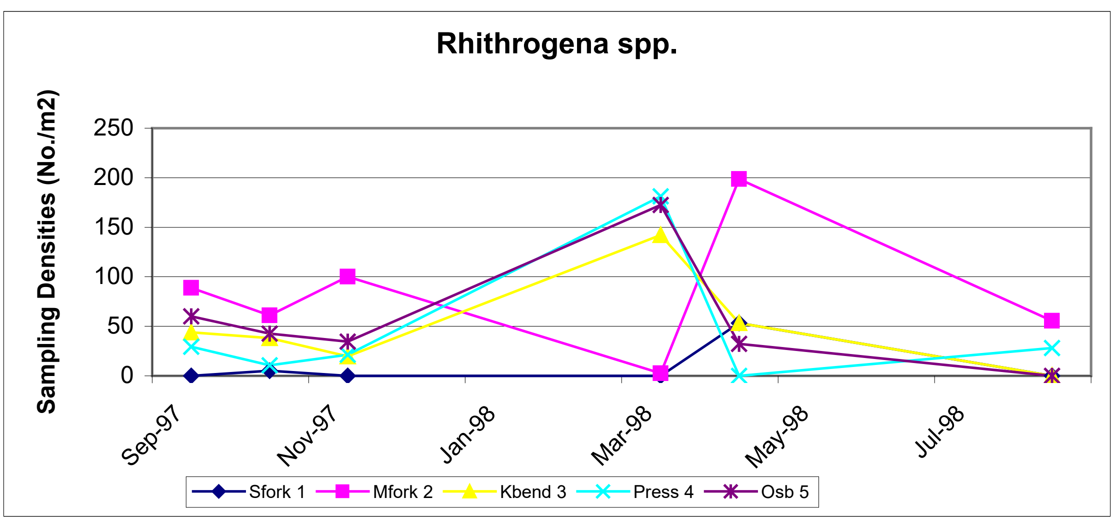


Figure 8. (Con't) Variability in mayfly densities (#/m^2) by site through the annual cycle.

The Heptageniidae was also relatively abundant in this study with the genus *Rhithrogena* comprising the largest component of the family. Heptageniid species highest mean annual densities (Figure 7) occurred at Site two, the unregulated portion of the Flathead River, followed by Sites five, three and four, respectively. The highest densities (Figure 8) were observed in the November and April samples while the lowest was observed in August. There were a small number observed in the October and April samples at Site one. Maximum densities for Heptageniids minus *Rhithrogena* were found in the April sample (< 1566 individuals/m^2). *Rhithrogena* mean annual density (Figure 7) followed the same pattern of abundance at each site as the general Heptageniid family. The lowest density (Figure 8) was also observed in the August sample.

Leptophlebia, a common genus in the North and Middle Forks and main stem river was absent at all the sites in this study. The genus *Paraleptophlebia* was present in small numbers at Site two, the unregulated portion of the Flathead River, and sampled only on one date at Site one below Hungry Horse Dam. It was absent from all sites in the partially regulated main stem.

Plecoptera

Most stonefly species were either completely eliminated or very rare at Site one. Among those that did remain in small numbers below the dam in the South Fork was the Nemourid *Zapata* spp., Taeniopterygid *Taenionema* spp., Perlodid *Isoperla* spp., and the Capniid nymphs (Figure 9). *Zapata* spp. and *Taenionema* spp. had similar mean annual densities but timing of emergence was different (Figure 10). *Zapata* spp. were found September through March while *Taenionema* spp. were sampled October through April in the South Fork. *Isoperla* spp. and the Capniidae were only observed in low densities on two dates and one date, respectively, out of six sample dates in the South Fork below the dam.

Taenionema spp. was by far the most abundant stonefly sampled in this study. Abundance achieved maximum values at the partially regulated Sites four, three and five respectively (Figure 9) with the highest mean densities found in November (> 4900 individuals/m^2). Few or no nymphs were sampled for the August and September dates at all sites (Figure 10).

The Capniidae were the second most common stonefly family to occur and were observed in greatest abundance at the partially regulated Site four (Figure 9). Capniids decreased in abundance progressively to Sites two, five and three, respectively. Highest densities (Figure 10) were achieved in the March sample (> 2300 individuals m^2).

Isoperla spp. was most abundant in the spring samples (Figure 10). Abundance achieved maximum values at the partially regulated Site three (Figure 9), followed by the unregulated Site two, then Sites five, four and one, respectively. No *Isoperla* spp. was collected in the August and September samples. The family Perlodidae, to which the genus *Isoperla* belongs, represented the third most abundant stonefly mean annual density in the study (Appendix B). The family Chloroperlidae closely

followed this group in abundance with Perlid nymphs comprising substantially the lowest densities. *Pteronarcella* spp. annual mean density was highest at Site three (Figure 9) and decreased downstream at Sites five and four, respectively. *Pteronarcella* spp. was collected on only one date out of six sample dates at Site one, the South Fork below Hungry Horse Dam (September), and at Site two the unregulated portion of the Flathead River (August) (Figure 10).

Claassenia spp. and *Hesperoperla* spp. had the highest mean annual densities for the family Perlidae in this study. Density was highest at Site two for *Claassenia* spp. while density was highest at the partially regulated Site three for *Hesperoperla* spp. (Figure 9). *Claassenia* spp. density declined substantially at Sites five, three and four, respectively. *Hesperoperla* spp. nymphal densities at Sites three and five were relatively similar. Densities decreased to even lower values at Sites four and two, respectively. Both genera were absent from Site one.

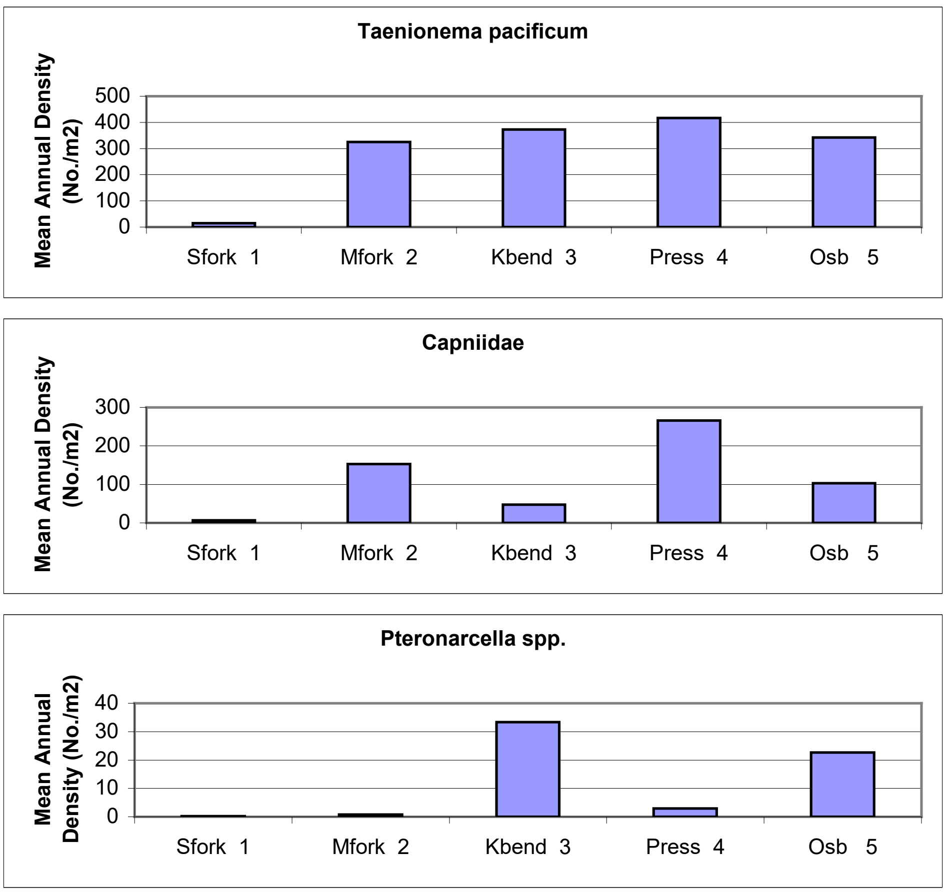
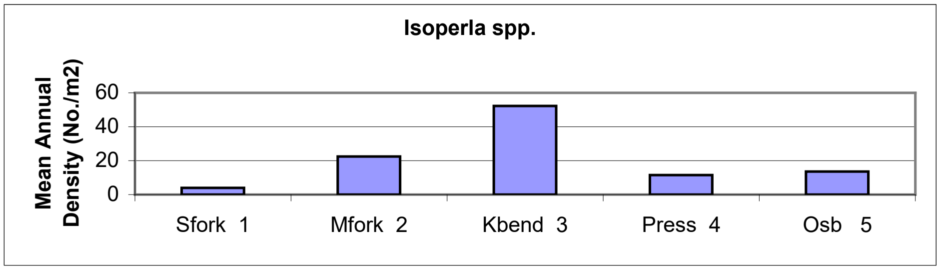


Figure 9. Mean annual density (#/m^2) of abundant stoneflies at each of the five sampling sites on the South Fork and main stem Flathead River. **(CONTINUED NEXT PAGE)**



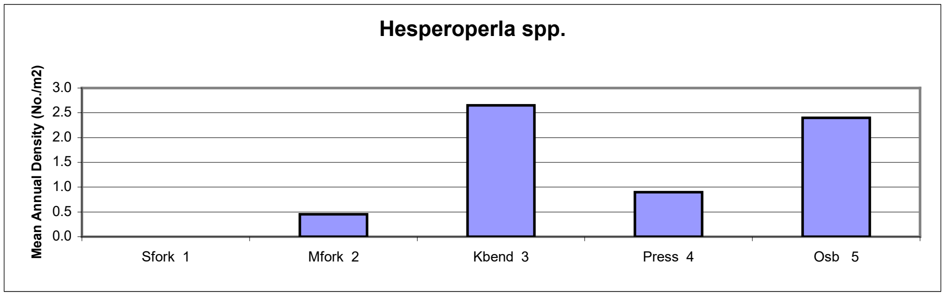
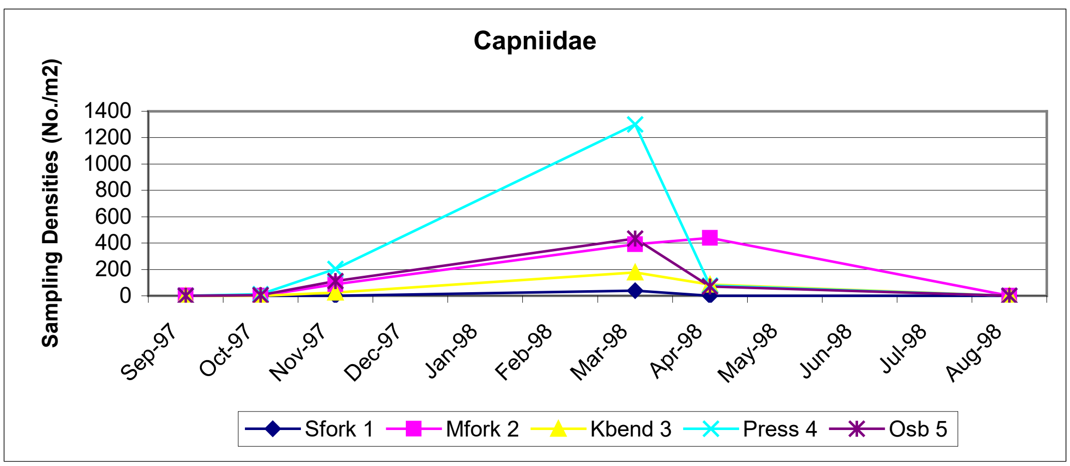


Figure 9. (Con't). Mean annual density (#/m^2) of abundant stoneflies at each of the five sampling sites on the South Fork and main stem Flathead River.



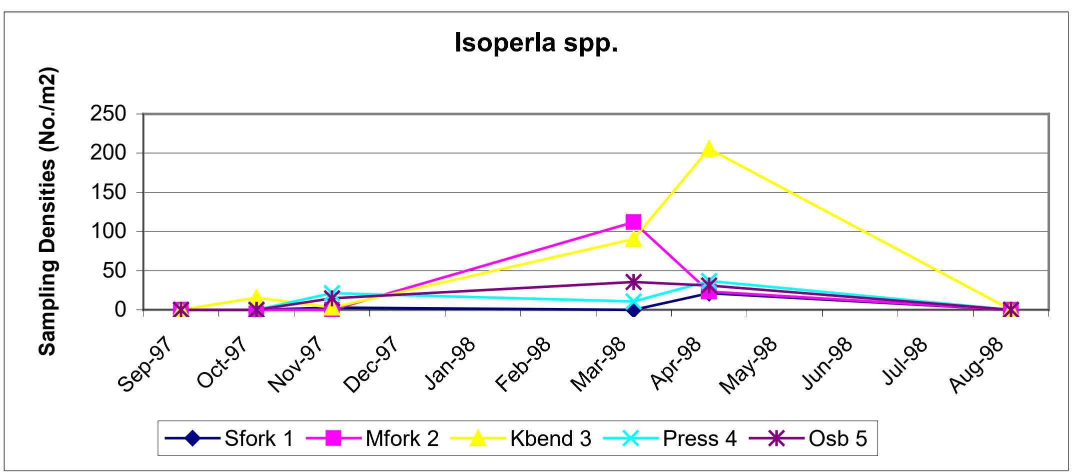


Figure 10. Variability in stonefly densities (#/m^2) by site through the annual cycle. **(CONTINUTED NEXT PAGE)**

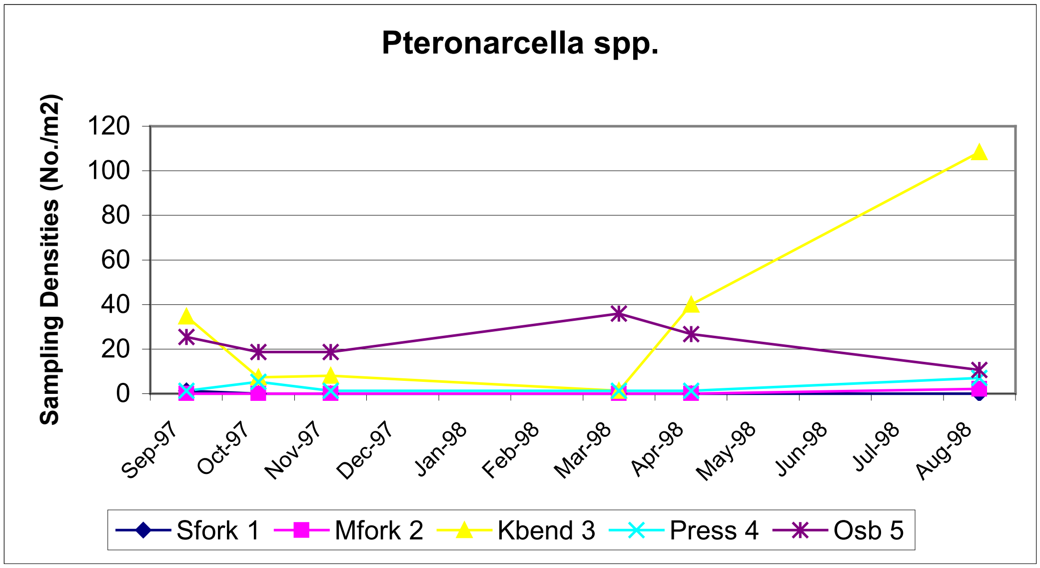
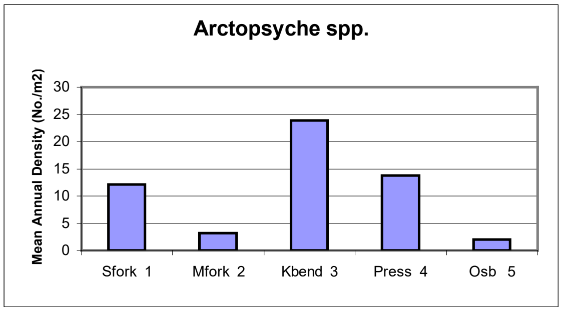


Figure 10. (Con't) Variability in stonefly densities (#/m^2) by site through the annual cycle.

<u>Trichoptera</u>

The net-spinning caddisflies were the most abundant of the Trichoptera collected in this study. Members of the family Hydropsychiidae occur abundantly in the unregulated and partially regulated waters of the Flathead River (Hauer et al. 1994). Highest mean annual densities of the genus *Hydropsyche* were found at the partially regulated Site three with declining but still high densities at the unregulated Site two and Site four, respectively (Figure 11). Numbers collected dropped off but were still fairly abundant at Site one, the South Fork below the dam. Timing of highest larval densities collected differed between the unregulated Site two (March) and the partially regulated Sites three and four (Aug-September). The highest density collected at Site one, the South Fork below the dam, occurred in April (Figure 12). The genus *Arctopsyche* exhibited a different pattern in larval densities. Similar to *Hydropsyche* species, the highest mean annual density of *Arctopsyche* spp. was exhibited at the partially regulated Site three. Mean annual densities decreased from there to Sites four and one (regulated site), respectively. Site two (unregulated site) and Site five (Old Steel Bridge) had the lowest observed densities. The highest larval densities were collected in September from the regulated Site one and the partially regulated Site three and in August from the partially regulated Sites three and four (Figure 12).



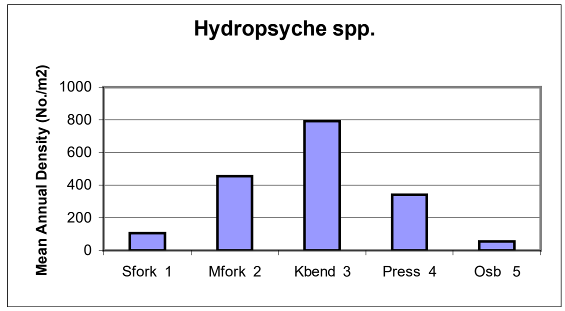
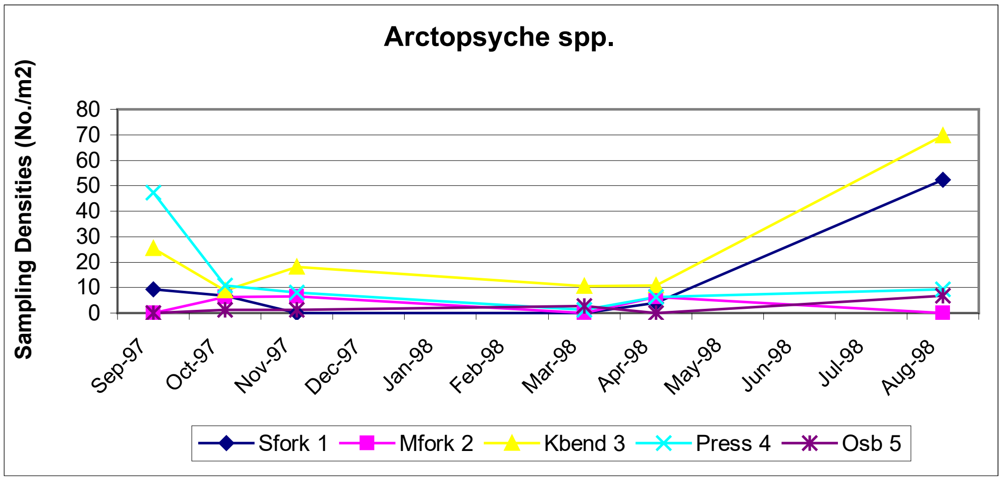


Figure 11. Mean annual density (#/m^2) of abundant caddisflies at each of the sampling sites on the South Fork and main stem Flathead River.



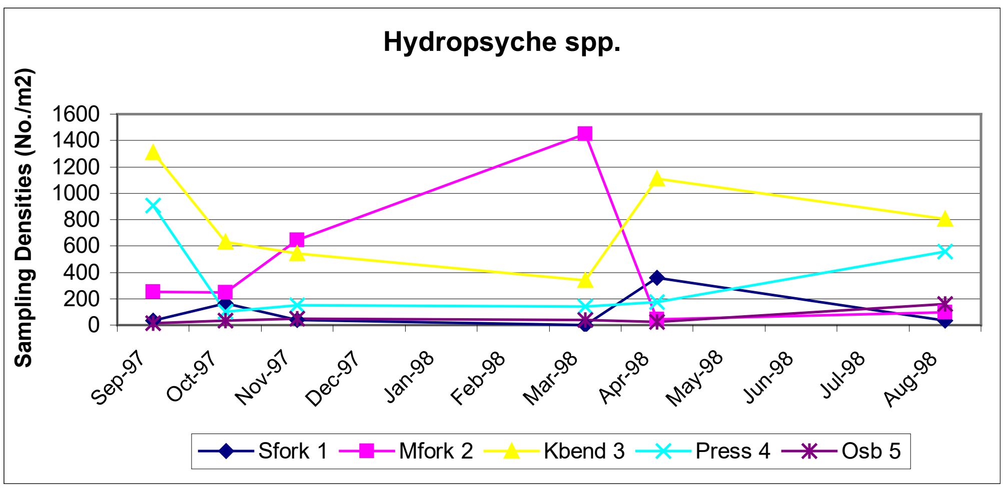


Figure 12. Variability in caddisfly densities (#/m^2) by site through the annual cycle.

DISCUSSION

DISCHARGE AND TEMPERATURE

Discharge from Hungry Horse Dam has followed a predictable annual schedule since operation began in 1952, primarily for electrical generation and flood control. Therefore, daily changes in discharge are unpredictable as compared with the North and Middle Forks of the Flathead River that exhibit a typical snowmelt hydrograph. During this study discharge out of the regulated South Fork changed dramatically not only seasonally, but also on a weekly basis (Figures 3 & 4). The North and Middle Forks combined represent about 60% and the South Fork 40% of the annual flow of the main stem Flathead River at Columbia Falls (Hauer et al. 1994). So the partially regulated main stem hydrograph is closely tied to Hungry Horse Dam discharge regime a great portion of the year. Other studies have shown that volume fluctuations in discharge increased stress and vulnerability on most components of the macroinvertebrate community in the portion of channel affected by flow fluctuation (varial zone) of the main stem (Perry and Graham 1981, Perry 1984, Hauer et al. 1994). The results of this study suggest that this has not changed. However, since 2001, flow fluctuations have occurred at a gradual ramping rate (Marotz et al. 2000). The Northwest Power Planning Council's Mainstem Amendment document for 2002-16 had in it operational strategies thought to have significant biological benefits to fish that live upstream and downstream of federal hydropower dams. Among them were daily and hourly maximum ramp up and ramp down rates for Hungry Horse Dam which were initiated and made dependant on a tiered flow range of daily flows measured in the main stem at Columbia Falls. Basically the lower the flow is at Columbia Falls the lower the rate of change is per day and per hour, as well as the maximum amount of discharge allowed out of the dam. This strategy would narrow the varial zone band impacted by fluctuating flows and maximize habitat for optimal biological production (ie. aquatic insects). A future study could incorporate a portion of time quantifying biologically this change in discharge strategy.

Hypolimnetic releases from Hungry Horse Reservoir still alter the natural thermal regime of the South Fork and main stem Flathead River during the months of November through June when selective withdrawal is not operational. From mid-March through the end of June before selective withdrawal begins, the natural, unregulated flow regime of the North and Middle Forks is warmer than Hungry Horse Dam hypolimnetic releases. Selective withdrawal begins in June and the natural thermal regime is maintained until use of the device ends sometime in October. In both the South Fork and partially regulated main stem Flathead River the thermal impact of hypolimnetic released water ceases during this critical period of insect and fish growth.

Many insects have strict temperature requirements and minor alterations in temperature can have major effects. Sweeney (1984) reports that temperature directly affects rates of feeding, assimilation, respiration, food conversion efficiencies, enzymatic kinetics and endocrine processes. A temperature summation criterion often gives a picture of insect life histories (Lehmkuhl 1972, Stanford 1975).

The degree-day is an example of a summation criterion used in the study of insect life histories. Mean daily temperatures are summed for a given period of time to give a comparison of the cumulative heat load in different areas. Perry and Graham (1982) showed that colder summer temperatures (pre-selective withdrawal) at Kokanee Bend (Site three) slowed summer growth rates. The total number of degree-days (graphed as mean daily temperatures summed by month) was less in the partially regulated sections of the river from June through September of 1980 due to coldwater discharge from Hungry Horse Dam (Figure 13). Compare this to water year 1998 of this study (Figure 14). The total number of degree-days in the partially regulated section was intermediate between the Middle and North Forks of the Flathead for the same time period, suggesting an improvement of summer growth rates in that section of the river. The regulated South Fork has acquired the greatest benefit in degree-day accumulation from selective withdrawal. Mean daily temperatures are summed for each month, season, and year for the three study areas during water year 1979, 1980, and 1981 (Appendix C1) and for the three forks of the Flathead River and main stem at Columbia Falls during water years 1997 and 1998 (Appendix C2). When comparing the monthly and annual temperature accumulations in the South Fork for the years with and without selective withdrawal, there is an average difference of 860 degree-days. Whereas comparing the difference between the partially regulated site (Columbia Falls) between with and without years yields an average of 340 degree-days. The greatest gains occurred during the critical summer months of fish and insect growth. Hauer et al. (1994) and Perry et al. (1981, 1982) reported that the timing of life cycles, growth rates and emergence times of insects are adjusted according to the prevailing temperatures of a water year. These data show an improved heat budget downstream of Hungry Horse Dam since the operation of selective withdrawal began, bringing it more in line with the unregulated North and Middle Forks of the Flathead River system.

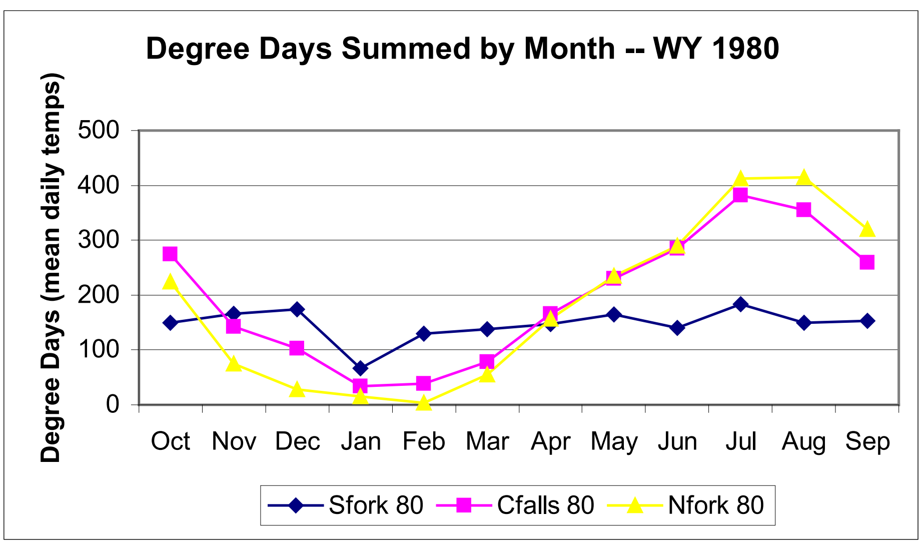


Figure 13. Degree days (mean daily temperatures summed by month) for unregulated (North Fork), partially regulated (main stem at Columbia Falls), and regulated (South Fork) areas of the Flathead River during the 1980 water year.

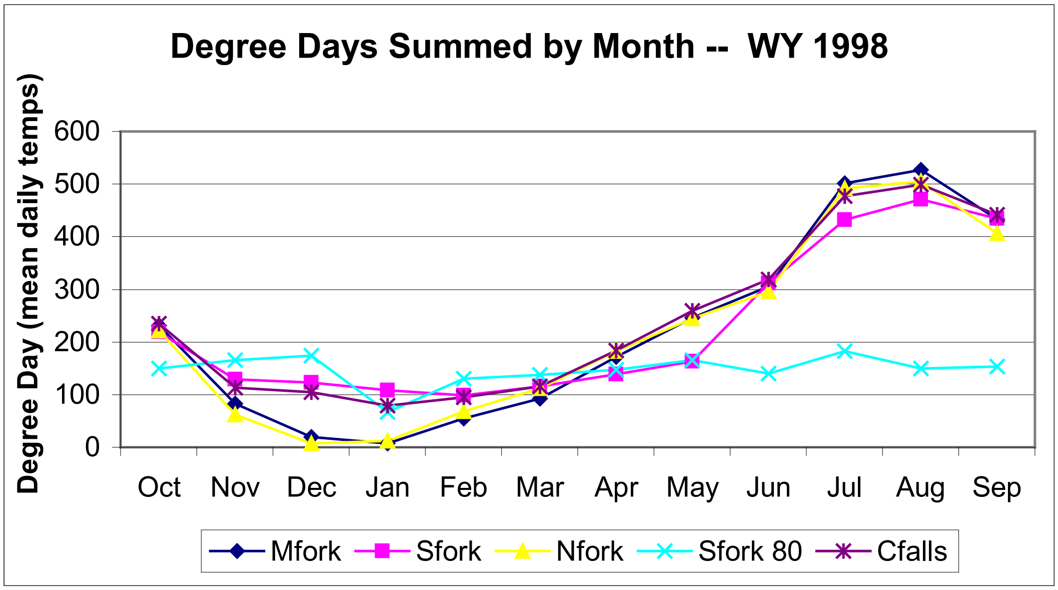


Figure 14. Degree days (mean daily temperatures summed by month) for unregulated North and Middle Fork), partially regulated (main stem at Columbia Falls), and regulated (South Fork) areas of the Flathead River during the 1998 water year and the regulated South Fork in the 1980 water year.

SESTON

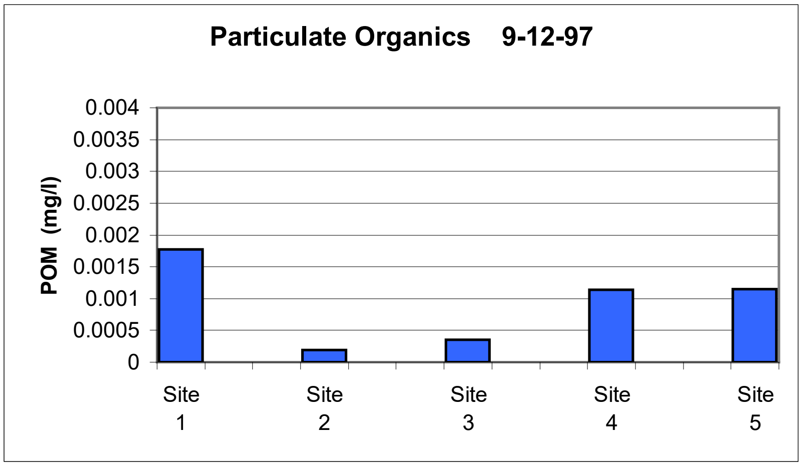
Wetzel and Likens (1990) illustrates that particulate organic matter (POM) and dissolved organic material (DOM) become available for degradation when plants and animals die. And the conversion of POM and DOM back into their inorganic constituents is a direct result of complete decomposition of these organic products. Nearly all the organic carbon in natural waters is in the form of dissolved organic carbon (DOC) while the rest is made up of dead particulate organic carbon (POC) (Wetzel 1984). Organic carbon content can be estimated by direct analysis of POM dry weight (Wetzel et al. 1990). Perry (1984) reported seston information as particulate organic carbon (POC) and dissolved organic carbon (DOC) while Hauer et al. (1994) reported seston as particulate organic matter (POM) and total suspended solids (TSS). Since a correlation exists between POM and POC, a comparison can be made between the work of Perry (1984), Hauer et al. (1994), and this study. Regrettably, the lack of seston data through the annual cycle from this study makes it nearly impossible to draw any comparisons with the previous works.

Perry (1984) reported that pre-selective withdrawal annual means of total particulate organic carbon (POC) in mg/l with minimum discharge out of Hungry Horse Dam were lowest in the South Fork (Site one), highest at the unregulated Middle Fork (Site two), and intermediate at Kokanee Bend (Site three). Hauer et al. (1994) found that Sites three, four and five had the highest annual mean POM concentrations, substantially greater than that found at Sites one and two. In their study the partially regulated main stem achieved highest POM concentrations prior to spring runoff whereas Perry (1984) reported highest POC values in the partially regulated main stem during the same time of year only while Hungry Horse Dam was in full generation. This was attributed to a larger component of sloughed periphyton from

the substrate and re-suspended material in the partially regulated main stem at high discharge. Perry (1984) reported mean annual values of total POC were twice as high at the station below Libby Dam with selective withdrawal as at the station below Hungry Horse with the hypolimnetic drain. With the onset of selective withdrawal and the discharge of more productive epilimnetic water, one would expect higher seston values in the South Fork samples through the operating season of selective withdrawal compared with a similar season hypolimnetic release. This may have shown up in our study during the September sample when Site one had the greatest seston value of all the sampling sites (Figure 15). Hauer et al. (1994) reported POC values for the two coinciding sampling dates an order of magnitude higher than any values this study yielded. The October sample in this study produced a large value for seston at Site five (Old Steel Bridge), the lowest site on the partially regulated Flathead, which was the only value similar to those report by Hauer et al. (1994). The POM value at Site five was inordinately high compared with the other four sample sites in October. The October date does correspond with leaf fall and in the main stem Flathead River with its larger riparian corridor, one might expect to see a higher POM value than sites upstream. This was not necessarily reflected at Sites three (Kokanee Bend) and four (Pressentine) when compared with the value at Site two (unregulated Middle Fork).

INVERTEBRATES

Even with the onset of selective withdrawal and its effect on summer temperatures in the regulated and partially regulated sections of the Flathead, annual differences still occur with variable discharge out of Hungry Horse reservoir. Hauer et al. (1994) as well as Stanford (1975), Hauer (1980), and Perry (1984) all observed that the macroinvertebrate community responded similarly to the biological and physical template of the regulated and partially regulated Flathead River system. Density of macroinvertebrates is usually highly variable throughout an annual cycle (Hauer et al. 1994), particularly for species that grow rapidly over a very short time period (univoltine species). Disturbance by repeated change in discharge both seasonal and annual, impact species that are longer-lived (univoltine or multiyear life cycle species) by constraining niche requirements of life histories (Hauer et al. 1994). With this stated, this study made some simple observations and comparisons gleaned from the data collected. Hauer and Stanford (1982a), Stanford, Hauer, and Ward (1988), and Hauer et al. (1994) reported that the upstream dominant caddisfly, *Arctopsyche grandis* replaced *Hydropsyche* spp. as the dominant member of the trophic group in the partially regulated main stem. This may have been due to flow fluctuations and reduced summer temperatures in the main stem from hypolimnetic releases. Perry et al. (1981) also found that *Arctopsyche grandis* was more abundant than other Hydropsychid species at the regulated Site one (South Fork below Hungry Horse Dam) and the partially regulated site (Site three).



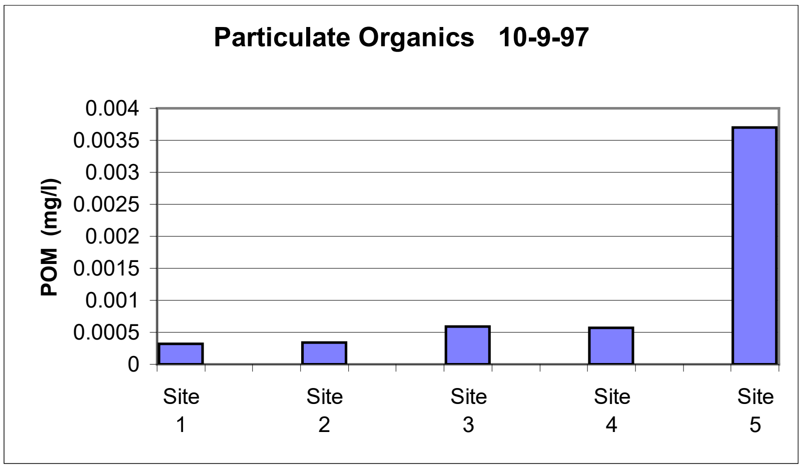


Figure 15. Particulate Organic Matter at each of the five sample sites on the Flathead River on two sampling dates.

We observed densities of *Hydropsyche* spp. to be higher than *Arctopsyche* spp. at all five sampling sites, especially at partially regulated Sites three and four. This does suggest a shift has occurred in this trophic group of caddis due to the effects of selective withdrawal in the partially regulated and regulated Flathead. It should be noted that at the unregulated Site two the same relationship between the two genera was observed (densities of *Hydropsyche* spp. higher than *Arctopsyche* spp.).

Among the stoneflies, *Taenionema pacificum* was the most abundant taxa at all five sampling sites. Hauer et al. (1994) and Perry et al. (1981) both reported that *T. pacificum* nymphs were most abundant at all the main stem partially regulated sites sampled. We found these nymphs and the Nemourid nymph, *Zapada* spp. to be the most prevalent stoneflies in the regulated South Fork (Appendix B) whereas Hauer et al. (1994) found *Capnia* spp., *T. pacificum* and *Isoperla fulva* nymphs to be the most prevalent.

Perry et al. (1981) reported that most of the mayfly species observed in the study were more abundant at the control site, the unregulated portion of the Flathead. Perry (1984) postulated that lower numbers at the partially regulated site could be attributed to a reduction in fine particulate organic matter in the substrate caused by clear water discharges from the dam. Webster, Benfield, and Cairns (1979),

developed a model of the effects of impoundment on organic matter transport that predicted no deposition of benthic particulate organic matter below a reservoir due to repeated rising discharges. These discharges suspend smaller and lighter particles and transport them downstream. Many mayflies are found in the shallow water along waters edge during their early developmental stages. These shoreline areas were particularly affected by fluctuating flows. We observed that among the less abundant mayflies, the unregulated portion of the Flathead (Site two) did have higher densities than the regulated and partially regulated sites, which are findings similar to Perry et al. (1981). But when it came to the two most abundant mayfly genera, *Baetis* spp. and *Ephemerella* spp. this was not true. Both genera were twice and three times more abundant in the regulated South Fork than the unregulated Flathead, respectively. The *Ephemerella* spp. mean annual density observed in the regulated South Fork was far higher than those reported by Perry (1984) and Hauer et al. (1994). It seems that the observed sampling densities of both genera at Site one through the year are a result of more than just a drift component from Fawn Creek upstream. Perry (1984) reported *Ephemerella inermis* and *Baetis tricaudatus* predominated in the Kootnai River near Libby Dam and noted that they are species with several generations per year (multivoltine) and postulated that their prolific reproduction was enough to withstand population losses due to stranding and downstream drift caused by flow fluctuations. Perry (1984) also found that *E. inermis* was not able to tolerate the thermal conditions in the pre-selective withdrawal South Fork and *B. tricaudatus* was much reduced. The improved heat budget below Hungry Horse Dam with the use of selective withdrawal could explain the change in dominance of *Baetis* and *Ephemerella* species. The increase at the partially regulated Sites three and four could indicate an increase in fine particulate organic matter in the substrate. The ramped or step-wise and elongated nature of peaking and waning discharge reservoir releases may have changed how these smaller and lighter particles are transported downstream. Thus allowing for a more normal deposition and transport pattern to occur which results in less flushing of these materials out of the varial zone. These ramped discharges also bring a slower rate of change in velocity, which would present a lesser stimulus for these genera to enter the drift therefore increasing their densities.

The results presented in this study are a snapshot in time and present indication that there are definitive changes for the macroinvertebrate community brought about by the use of selective withdrawal at Hungry Horse Dam. Water temperature data is quite conclusive showing positive changes in degree-day accumulation in both the regulated and partially regulated Flathead. It is our hope that the data presented in this study would be useful for future projects and when combined with information from previous studies could give a clearer picture of any trends occurring in the macroinvertebrate community of the regulated and partially regulated Flathead River. Future investigations might include the determination of macroinvertebrate growth rates and biomass estimates and possibly how the transport of organic matter and insect drift is affected by ramped discharge releases out of Hungry Horse Dam. These investigations could lead to further operational recommendations to benefit the aquatic biota of the main stem Flathead River.

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Appendix A

Completed Seston

Results of seston sampling for two dates, 12-Sep-1997 and 9-Oct-1997 in all five sampling areas. Ash free dry weight averages are divided by their averaged water volume filtered to yield mg/l. And Seston sampling water velocities and volume sampled by net for all six sample dates.

Table A1. Ash free dry weights (AFDW) and water volume filtered for each sample and their calculated means for the September 1997 sample date.

Seston Weights in Grams 12-Sep-97

Glass Filter AREA	(GF)	**Sample + GF** DW	**Sample** DW	**Sample + GF** AFDW	**Sample** AFDW
SF	0.2767	1.2302	0.9535	0.4691	0.1924
	0.2537	1.5006	1.2469	0.5354	0.2817
	0.2534	1.159	0.9056	0.46	0.2066
MF	0.2612	0.3115	0.0503	0.2746	0.0134
	0.2609	0.2992	0.0383	0.2706	0.0097
	0.2453	0.298	0.0527	0.2599	0.0146
KB	0.2469	0.3652	0.1183	0.2741	0.0272
	0.2593	0.3369	0.0776	0.276	0.0167
	0.2543	0.4692	0.2149	0.2897	0.0354
P	0.2558	0.8696	0.6138	0.3525	0.0967
	0.259	1.2977	1.0387	0.3752	0.1162
	0.238	1.306	1.068	0.3897	0.1517
OSB	0.2403	1.5161	1.2758	0.3618	0.1215
	0.2479	0.888	0.6401	0.3463	0.0984
	0.2353	0.5236	0.2883	0.3228	0.0875
GLASS	0.2525	0.2525	<---------->	0.2517	-0.0008
FILTERS	0.244	0.2437	<---------->	0.2436	-0.0004
ONLY	0.247	0.2468	<---------->	0.2471	0.0001
GF	0.2614	0.2613	<---------->	0.2616	0.0002
GF	0.2516	0.2519	<---------->	0.252	0.0004

AREA	**mg** DW	**mg** AFDW	mg DW - AFDW	CUBIC M	LITERS	Mg/L AFDW		Mean Mg/L
SF	953.5	192.4	761.1	146.4	146483.4	0.001313		
	1246.9	281.7	965.2	110.2	110262.8	0.002555	Site 1	0.001777
	905.6	206.6	699	141.2	141280.5	0.001462		
MF	50.3	13.4	36.9	56.9	56932.43	0.000235		
	38.3	9.7	28.6	61.9	61935.28	0.000157	Site 2	0.000194
	52.7	14.6	38.1	77	77043.89	0.00019		
KB	118.3	27.2	91.1	53.5	53530.5	0.000508		
	77.6	16.7	60.9	81.9	81946.68	0.000204	Site 3	0.000349
	214.9	35.4	179.5	105.5	105560.1	0.000335		
P	613.8	96.7	517.1	119.6	119668.2	0.000808		
	1038.7	116.2	922.5	113.4	113464.6	0.001024	Site 4	0.001137
	1068	151.7	916.3	96	96054.72	0.001579		
OSB	1275.8	121.5	1154.3	90	90051.3	0.001349		
	640.1	98.4	541.7	87.1	87149.65	0.001129	Site 5	0.00115
	288.3	87.5	200.8	90	90051.3	0.000972		

Table A2. Ash free dry weights (AFDW) and water volume filtered for each sample and their calculated means for the October 1997 sample date.

Seston Weights in Grams 9-Oct-97

Glass Filter AREA	(GF)	**Sample + GF** DW	**Sample** DW	**Sample + GF** AFDW	**Sample** AFDW
SF	0.2786	0.4212	0.1426	0.3032	0.0246
	0.2753	0.4166	0.1413	0.2954	0.0201
	0.2767	0.485	0.2083	0.3143	0.0376
MF	0.2815	0.3758	0.0943	0.3072	0.0257
	0.2771	0.3731	0.096	0.2995	0.0224
	0.2792	0.3242	0.045	0.2917	0.0125
KB	0.2799	0.6883	0.4084	0.3648	0.0849
	0.2799	0.3698	0.0899	0.3168	0.0369
	0.2736	0.3574	0.0838	0.306	0.0324
P	0.2726	0.3564	0.0838	0.3023	0.0297
	0.2774	0.3904	0.113	0.3135	0.0361
	0.2739	0.3882	0.1143	0.3138	0.0399
OSB	0.274	1.1394	0.8654	0.3655	0.0915
	0.275	3.3557	3.0807	0.6639	0.3889
	0.2789	2.5777	2.2988	0.5205	0.2416

AREA	**mg** DW	**mg** AFDW	mg DW - AFDW	CUBIC M	LITERS	MG/L AFDW		Mean Mg/L
SF	142.6	24.6	118	60.95	60984.74	0.000403		
	141.3	20.1	121.2	72.4	72441.27	0.000277	Site 1	0.000321
	208.3	37.6	170.7	133.8	133876.3	0.000281		
MF	94.3	25.7	68.6	56.4	56432.15	0.000455		
	96	22.4	73.6	70.2	70240.01	0.000319	Site 2	0.000338
	45	12.5	32.5	51.9	51929.58	0.000241		
KB	408.4	84.9	323.5	102.2	102258.3	0.00083		
	89.9	36.9	53	76.3	76343.49	0.000483	Site 3	0.000592
	83.8	32.4	51.4	70.2	70240.01	0.000461		
P	83.8	29.7	54.1	63.7	63736.31	0.000466		
	113	36.1	76.9	63.7	63736.31	0.000566	Site 4	0.000571
	114.3	39.9	74.4	58.6	58633.4	0.00068		
OSB	865.4	91.5	773.9	67.7	67738.59	0.001351		
	3080.7	388.9	2691.8	63	63035.91	0.006169	Site 5	0.003696
	2298.8	241.6	2057.2	67.7	67738.59	0.003567		

SEPTEMBER 12, 1997

1300 hrs	DISCHARGE:
South Fork	1792 cfs
North Fork	942 cfs
Middle Fork	1058 cfs
@ C Falls	4022 cfs

Seston Sampling Water Velocities @ Net Mouth---Meters Per Second

Location	A	B	C	Time (minutes)	Time (seconds)
South Fork	.85	.64	.82	35	2100
Middle Fork	.34	.37	.46	34	2040
Kokanee Bend	.34	.52	.67	32	1920
Pressentine Bar	.76	.72	.61	32	1920
Old Steel Br.	.61	.59	.61	30	1800

Volume of Water Sampled by Seston Nets---Cubic Meters

Location	A	B	C
South Fork	146.4	110.2	141.2
Middle Fork	56.9	61.9	77.0
Kokanee Bend	53.5	81.9	105.5
Pressentine Bar	119.6	113.4	96.0
Old Steel Br.	90.0	87.1	90.0

Net Mouth Area---820 square centimeters

October 9, 1997

1300 hrs DISCHARGE:

South Fork	435 cfs
North Fork	1840 cfs
Middle Fork	1502 cfs
@ C Falls	4185 cfs

Seston Sampling Water Velocities @ Net Mouth---Meters Per Second

Location	**A**	**B**	**C**	**Time (minutes)**	**Time (seconds)**
South Fork	.43	.46	.85	32	1920
Middle Fork	.37	.46	.34	31	1860
Kokanee Bend	.67	.50	.46	31	1860
Pressentine Bar	.37	.37	.34	35	2100
Old Steel Br.	.43	.40	.43	32	1920

Volume of Water Sampled by Seston Nets---Cubic Meters

Location	**A**	**B**	**C**
South Fork	54.2---67.7	72.4	133.8
Middle Fork	56.4	70.2	51.9
Kokanee Bend	102.2	76.3	70.2
Pressentine Bar	63.7	63.7	58.6
Old Steel Br.	67.7	63.0	67.7

Net Mouth Area---820 square centimeters
South Fork A---was 80 to 100 % submerged

NOVEMBER 14, 1997

1200 hrs DISCHARGE:

South Fork	1490 cfs
North Fork	930 cfs
Middle Fork	1020 cfs
@ CFalls	3673 cfs

Seston Sampling Water Velocities @ Net Mouth---Meters Per Second

Location	**A**	**B**	**C**	**Time (minutes)**	**Time (seconds)**
South Fork	.37	.73	.91	35	2100
Middle Fork	.40	.41	.37	36	2160
Kokanee Bend	.53	.53	.61	35	2100
Pressentine Bar	.35	.40	.35	32	1920
Old Steel Br.	.73	.76	.76	30	1800

Volume of Water Sampled by Seston Nets---Cubic Meters

Location	**A**	**B**	**C**
South Fork	63.7	125.7	156.7
Middle Fork	70.8	72.6	65.5
Kokanee Bend	91.2	91.2	105.0
Pressentine Bar	55.1	63.0	55.1
Old Steel Br.	107.8	112.2	112.2

Net Mouth Area--- 820 square centimeters

MARCH 5, 1998

1200 hrs	DISCHARGE:	
	South Fork	2770 cfs
	North Fork	431 cfs
	Middle Fork	416 cfs
	@C Falls	3574 cfs

Seston Sampling Water Velocities @ Net Mouth---Meters Per Second

Location	**A**	**B**	**C**	**Time (minutes)**	**Time (seconds)**
South Fork	.53	.61	.67	38	2280
Middle Fork	.37	.37	.43	38	2280
Kokanee Bend	.64	.61	.70	35	2100
Pressentine Bar	.27	.27	.27	36	2160
Old Steel Br.	.49	.43	.55	34	2040

Volume of Water Sampled by Seston Nets---Cubic Meters

Location	**A**	**B**	**C**
South Fork	99.1	114.0	125.3
Middle Fork	69.2	69.2	80.4
Kokanee Bend	110.2	105.0	120.5
Pressentine Bar	47.8	47.8	47.8
Old Steel Br.	82.0	71.9	92.0

Net Mouth Area---820 square centimeters

APRIL 2, 1998

1200 hrs	DISCHARGE
South Fork	500 cfs
North Fork	1351 cfs
Middle Fork	1648 cfs
@C Falls	3658 cfs

Seston Sampling Water Velocities @ Net Mouth---Meters Per Second

Location	**A**	**B**	**C**	**Time (minutes)**	**Time (seconds)**
South Fork	.55	.73	.61	32	1920
Middle Fork	.43	.49	.43	32	1920
Kokanee Bend	.47	.52	.55	33	1980
Pressentine Bar	.40	.51	.44	35	2100
Old Steel Br.	.46	.52	.53	33	1980

Volume of Water Sampled by Seston Nets---Cubic Meters

Location	**A**	**B**	**C**
South Fork	86.6	114.9	96.0
Middle Fork	67.7	77.2	67.7
Kokanee Bend	76.3	84.4	89.3
Pressentine Bar	68.9	87.8	75.8
Old Steel Br.	74.7	84.4	86.0

Net Mouth Area---820 square centimeters

AUGUST 6, 1998

		DISCHARGE	
	0900 hrs	South Fork	3646 cfs
	1200 hrs	North Fork	2004 cfs
	1200 hrs	Middle Fork	1517 cfs
	1200 hrs	@ C Falls	7646 cfs

Seston Sampling Water Velocities @ Net Mouth---Meters Per Second

Location	**A**	**B**	**C**	**Time (minutes)**	**Time (seconds)**
South Fork	.35	.52	.55	34	2040
Middle Fork	.35	.41	.35	33	1980
Kokanee Bend	.21	.27	.27	A&B--37 C--31	A&B--2220 C--1860
Pressentine Bar	.15	.14	.15	30	1800
Old Steel Br.	.21	.21	.21	30	1800

Volume of Water Sampled by Seston Nets---Cubic Meters

Location	**A**	**B**	**C**
South Fork	58.55	86.99	92.00
Middle Fork	56.83	66.57	56.83
Kokanee Bend	38.23	49.15	41.18
Pressentine Bar	22.14	20.66	22.14
Old Steel Br.	31.00	31.00	31.00

Net Mouth Area---820 square centimeters

Appendix B

Macroinvertebrate Density Estimates

Calculated densities of insect taxa from the combined gross and subsampled picks by order and sample site for all sampling dates. Total annual and mean annual densities included.

Table B1. Calculated mean densities (#/m^2) of insect taxa from Emphemeroptera for each sample site and sampling date. Total annual densities of insect taxa calculated by sample date and site. Mean annual densities calculated by sample site for each taxa.

EPHEMEROPTERA

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	142.2	48.4	272	1076	616	269.3	2423.9	404
Baetidae	S. Fork	488	194.7	116.4	21.3	4896	175.1	5891.5	981.9
baetis spp.	K. Bend	45.3	7.8	67.6	155.6	348	242.7	867	144.5
	Press	37.3	128	10.7	96	99.6	116.9	488.5	81.4
	Osb	4	9.3	6.9	21.3	18.1	84	143.6	23.9
	Total	716.8	388.2	473.6	1370.2	5977.7	888	9814.5	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	0	0	0	0
Ephemerellidae	S. Fork	0	0	0	0	0	0	0	0
Ephemerella grandis	K. Bend	0	0	0	0	0	0	0	0
	Press	0	4	0	1.3	0	0	5.3	0.9
	Osb	0	0	0	0	0	0	0	0
	Total	0	4	0	1.3	0	0	5.3	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	9.8	89.3	1021.3	1072	374.2	12.3	2578.9	429.8
ephemerella spp.	S. Fork	10.7	109.3	1401.8	152.9	6069.3	62.2	7806.2	1301
	K. Bend	0	255.2	952.9	792.9	2586.7	23.1	4610.9	768.5
	Press	26.7	9.3	808	1354.7	1379.6	8.4	3586.7	597.8
	Osb	1.3	9.3	140.3	353.8	329.6	5.3	839.6	139.9
	Total	48.5	472.5	4324.2	3726.3	10739.4	111.3	19422.3	

Table B1. Con't

Site	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	0	1.3	1.3	0.2
timpanoga spp.	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	0	0	0	0	0	4.4	4.4	0.7
	Press	0	0	0	0	0	2.7	2.7	0.4
	Osb	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	8.4	8.4	

	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	30.7	26.2	41.3	20	4	6.9	129.1	21.5
Drunella doddsi	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	34.7	10.3	17.8	12	20	5.3	100.1	16.7
	Press	13.3	1.3	0	0	2.7	3.6	20.9	3.5
	Osb	6.7	8	4.8	1.3	1.3	2.7	24.8	4.1
	Total	85.4	45.8	63.9	33.3	28	18.5	274.9	

	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	0	0	0	0
caudatella spp.	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	0	0	0	0	0	0	0	0
	Press	0	0	0	0	0	3.1	3.1	0.5
	Osb	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	3.1	3.1	

Table B1. Con't

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	2.7	20.9	89.3	14.7	32	0	159.6	26.6
Siphlonuridae	S. Fork	0	26.7	0	0	0	0	26.7	4.4
ameletus spp.	K. Bend	0	0	0	0	0	0	0	0
	Press	0	0	0	1.3	0	1.8	3.1	0.5
	Osb	0	0	0	0	0	0	0	0
	Total	2.7	47.6	89.3	16	32	1.8	189.4	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	10.7	69.3	0	14.2	0	94.2	15.7
Leptophlebiidae	S. Fork	0	0	0	10.7	0	0	10.7	1.8
paraleptophlebia spp.	K. Bend	0	0	0	0	0	0	0	0
	Press	0	0	0	0	0	0	0	0
	Osb	0	0	0	0	0	0	0	0
	Total	0	10.7	69.3	10.7	14.2	0	104.9	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	119.1	144.9	744	0	750.6	36	1794.6	299.1
Heptageniidae	S. Fork	0	5.3	0	0	64	0	69.3	11.6
	K. Bend	61.3	97.1	101.3	0	112	227.6	599.3	99.9
	Press	122.7	21.3	96	0	124.4	0	364.4	60.7
	Osb	78.7	125.3	191.7	69.3	113.1	26.7	604.8	100.8
	Total	381.8	393.9	1133	69.3	1164.1	290.3	3432.4	

Table B1. Con't

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	88.9	60.9	100	2.7	198.6	55.5	506.6	84.4
rhithrogena spp.	S. Fork	0	5.3	0	0	53.3	0	58.6	9.8
	K. Bend	44	38	19.6	142.2	53.3	0	297.1	49.5
	Press	29.3	10.7	21.3	181.3	0	28	270.6	45.1
	Osb	60	42.7	34.7	172.4	32.3	0	342.1	57
	Total	222.2	157.6	175.6	498.6	337.5	83.5	1475	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	861.4	0	0	861.4	143.6
cinygma spp.	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	0	0	0	0	0	0	0	0
	Press	0	0	0	0	0	0	0	0
	Osb	0	0	0	0	0	0	0	0
	Total	0	0	0	861.4	0	0	861.4	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	21.3	33.3	54.6	9.1
epeorus spp.	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	0	0	0	0	0	0	0	0
	Press	0	0	0	0	7.1	0	7.1	1.2
	Osb	0	0	0	0	10.1	0	10.1	1.7
	Total	0	0	0	0	38.5	33.3	71.8	

Table B1. Con't

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	5.3	0	0	0	292.4	0	297.7	49.6
cinygmula spp.	S. Fork	0	0	0	0	53.3	0	53.3	8.9
	K. Bend	0	0	0	0	10.7	0	10.7	1.8
	Press	0	0	0	0	0	0	0	0
	Osb	0	0	0	0	7.5	0	7.5	1.3
	Total	5.3	0	0	0	363.9	0	369.2	

Table B2. Calculated mean densities (#/m²) of insect taxa from Pleceptera for each sample site and sampling date. Total annual densities of insect taxa calculated by sample date and site. Mean annual densities calculated by sample site for each taxa.

PLECOPTERA

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	5.3	24.9	40	112	39.1	0	221.3	36.9
Chloroperlidae	S. Fork	0	5.3	0	0	0	0	5.3	0.9
sweltsa spp.	K. Bend	0	2.1	29.3	35.6	48	0	115	19.2
	Press	0	0	10.7	0	37.3	0	48	8
	Osb	0	0	1.3	5.3	4.8	0	11.4	1.9
	Total	5.3	32.3	81.3	152.9	129.2	0	401	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	0	115.5	115.5	19.2
suwallia spp.	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	0	0	0	0	0	88.9	88.9	14.8
	Press	0	0	0	0	0	174.7	174.7	29.1
	Osb	0	0	0	0	0	150.7	150.7	25.1
	Total	0	0	0	0	0	529.8	529.8	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	0	0	0	0
paraperla spp.	S. Fork	0	2.7	0	0	0	0	2.7	0.4
	K. Bend	0	0	0	3.6	0	0	3.6	0.6
	Press	0	0	0	0	0	0	0	0
	Osb	0	0	0	0	0	0	0	0
	Total	0	2.7	0	3.6	0	0	6.3	

Table B2. Con't

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	8.9	0	0	10.7	19.6	0	39.2	6.5
Chloroperlidae	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	58.7	64.4	34.7	40.9	42.7	19.6	261	43.5
	Press	0	9.3	24	0	3.6	0	36.9	6.2
	Osb	2.7	22.7	22.4	14.2	4.8	0	66.8	11.1
	Total	70.3	96.4	81.1	65.8	70.7	19.6	403.9	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	22.6	20.9	112	10.7	19.6	2.1	187.9	31.3
Perlodidae	S. Fork	1.3	0	0	0	0	0	1.3	0.2
cultus spp.	K. Bend	0	2.1	91.6	1.3	21.3	1.8	118.1	19.7
	Press	1.3	0	1.3	10.7	16	1.8	31.1	5.2
	Osb	0	0	1.3	0	0	0	1.3	0.2
	Total	25.2	23	206.2	22.7	56.9	5.7	339.7	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	112	23.1	0	135.1	22.5
isoperla spp.	S. Fork	0	0	2.7	0	21.3	0	24	4
	K. Bend	0	15.6	2.7	90.2	205.4	0	313.9	52.3
	Press	0	0	21.3	10.7	36.9	0	68.9	11.5
	Osb	0	0	14.7	35.6	30.9	0	81.2	13.5
	Total	0	15.6	41.4	248.5	317.6	0	623.1	

Table B2. Con't

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	12.4	5.8	2.7	1.3	1.3	0	23.5	3.9
skwala spp.	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	5.3	3.1	1.3	0	0	0	9.7	1.6
	Press	0	0	8	5.3	0	0	13.3	2.2
	Osb	0	0	1.3	4	0	0	5.3	0.9
	Total	17.7	8.9	13.3	10.6	1.3	0	51.8	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	13.7	14.2	88	26.7	0	0	142.6	23.8
Perlodidae	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	41.3	24.4	56.9	8	0	0	130.6	21.8
	Press	0	13.3	34.7	0	0	0	48	8
	Osb	5.3	21.3	5.3	8.9	0	0	40.8	6.8
	Total	60.3	73.2	184.9	43.6	0	0	362	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	15.6	13.3	97.3	12	17.3	2.7	158.2	26.4
Perlidae	S. Fork	0	0	0	0	0	0	0	0
claassenia spp.	K. Bend	16	6.7	6.3	0	0	4	33	5.5
	Press	2.7	1.3	2.7	0	0	0	6.7	1.1
	Osb	12	12	15.4	7.6	12	0	59	9.8
	Total	46.3	33.3	121.7	19.6	29.3	6.7	256.9	

Table B2. Con't

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	0	0	0	0
calineuria spp.	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	0	0	0	0	0	0	0	0
	Press	0	0	0	0	0	0	0	0
	Osb	0	1.3	0	0	0	0	1.3	0.2
	Total	0	1.3	0	0	0	0	1.3	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	2.7	0	2.7	0.5
hesperoperla spp.	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	4	5.2	2.7	0	4	0	15.9	2.6
	Press	2.7	0	2.7	0	0	0	5.4	0.9
	Osb	1.3	1.3	0	4	4	4	14.6	2.4
	Total	8	6.5	5.4	4	10.7	4	38.6	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	16	7.1	4	10.7	10.7	0	48.5	8.1
Perlidae	S. Fork	0	0	2.7	0	0	0	2.7	0.4
	K. Bend	5.3	2.1	3.6	0	0	12.4	23.4	3.9
	Press	0	1.3	0	0	0	12.9	14.2	2.4
	Osb	6.7	14.7	24.3	0	2.7	26.7	75.1	12.5
	Total	28	25.2	34.6	10.7	13.4	52	163.9	

Table B2. Con't

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	0	2.1	2.1	0.4
Pteronarcyidae	S. Fork	1.3	0	0	0	0	0	1.3	0.2
pteronarcella spp.	K. Bend	34.7	7.4	8	1.3	40	108.4	199.8	33.3
	Press	1.3	5.3	1.3	1.3	1.3	7.1	17.6	2.9
	Osb	25.4	18.7	18.7	36	26.7	10.7	136.2	22.7
	Total	62.7	31.4	28	38.6	68	128.3	357	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	2.7	0	0	0	0	0	2.7	0.4
pteronarcys spp.	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	0	2.7	1.3	0	4	0	8	1.3
	Press	0	0	1.3	0	2.7	0	4	0.7
	Osb	0	0	0	0	0	0	0	0
	Total	2.7	2.7	2.6	0	6.7	0	14.7	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	13.3	1192	640	105.8	0	1951.1	325.2
Taeniopterygidae	S. Fork	0	26.7	22.2	10.7	32	0	91.6	15.3
Taenionema pacificum	K. Bend	5.3	137.6	1376.9	494.2	220	0	2234	372.3
	Press	0	34.7	997.3	1258.7	207.5	0	2498.2	416.4
	Osb	4	60	1337.1	474.7	179.2	0	2055	342.5
	Total	9.3	272.3	4925.5	2878.3	744.5	0	8829.9	

Table B2. Con't

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	2.7	0	0	0	2.7	0.4
Nemouridae	S. Fork	26.7	32	9.3	24.9	0	0	92.9	15.5
zapada spp.	K. Bend	0	4.3	7.1	0	0	0	11.4	1.9
	Press	0	0	2.7	0	0	0	2.7	0.4
	Osb	0	0	0	0	0	0	0	0
	Total	26.7	36.3	21.8	24.9	0	0	109.7	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	10.7	0	0	10.7	1.8
prostoia spp.	S. Fork	0	0	0	0	0	0	0	0
	K. Bend	0	0	0	0	0	0	0	0
	Press	0	0	0	10.7	0	0	10.7	1.8
	Osb	0	0	0	0	0	0	0	0
	Total	0	0	0	21.4	0	0	21.4	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	1.8	0	88	390.6	439.5	0	919.9	153.3
Capniidae	S. Fork	0	0	0	39.1	0	0	39.1	6.5
	K. Bend	0	0	24	176	85.3	0	285.3	47.6
	Press	0	12	202.7	1301.3	78.2	0	1594.2	265.7
	Osb	0	5.3	111.2	433.8	69.3	0	619.6	103.3
	Total	1.8	17.3	425.9	2340.8	672.3	0	3458.1	

Table B2. Con't

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	2.1	8.9	2.1	0	13.1	2.2
Plecoptera	S. Fork	10.7	0	0	0	0	0	10.7	1.8
	K. Bend	0	0	0	6.2	0	5.3	11.5	1.9
	Press	2.7	0	0	0	0	1.8	4.5	0.8
	Osb	0	1.3	2.1	8.9	2.1	0	14.4	2.4
	Total	13.4	1.3	4.2	24	4.2	7.1	54.2	

	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	0	0	0	0
Outliers	S. Fork	0	0	0	0	0	0	0	0
Perlodidae	K. Bend	0	0	0	0	1.3	0	1.3	0.2
isogenoides spp.	Press	0	0	0	0	0	0	0	0
	Osb	0	0	0	0	0	0	0	0
	Total	0	0	0	0	1.3	0	1.3	

	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	0	1.3	1.3	0.2
Perlidae	S. Fork	0	0	0	0	0	0	0	0
doroneuria spp.	K. Bend	0	0	0	0	0	0	0	0
	Press	0	0	0	0	0	0	0	0
	Osb	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	1.3	1.3	

Table B2. Con't

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	0	0	0	0
Perlodidae	S. Fork	0	0	0	0	0	0	0	0
diura spp.	K. Bend	0	0	0	0	0	0	0	0
	Press	0	0	0	0	1.3	0	1.3	0.2
	Osb	0	0	0	0	0	0	0	0
	Total	0	0	0	0	1.3	0	1.3	

Table B3. Calculated mean densities (#/m²) of insect taxa from Trichoptera for each sample site and sampling date. Total annual densities of insect taxa calculated by sample date and site. Mean annual densities calculated by sample site for each taxa.

TRICHOPTERA

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	6.2	6.6	0	6.2	0	19	3.2
Hydropsychidae	S. Fork	9.3	6.7	0	0	4	52.4	72.4	12.1
arctopsyche spp.	K. Bend	25.3	8.8	18.2	10.6	10.7	69.8	143.4	23.9
	Press	47.3	10.7	8	1.3	6.3	9.3	82.9	13.8
	Osb	0	1.3	1.3	2.7	0	6.7	12	2
	Total	81.9	33.7	34.1	14.6	27.2	138.2	329.7	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	251.6	247.1	646.7	1450.7	43.6	95.7	2735.4	455.9
Hydropsychidae	S. Fork	32.9	164	39.6	0	358.7	32	627.2	104.5
hydropsyche spp.	K. Bend	1309.3	632.7	544.4	341.3	1110.6	803.6	4741.9	790.3
	Press	908.7	102.6	152	142.7	175.1	557.7	2038.8	339.8
	Osb	13.3	33.4	49.3	39.1	23.7	160	318.8	53.1
	Total	2515.8	1179.8	1432	1973.8	1711.7	1649	10462.1	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	1.8	8	0	0	1.3	11.1	1.8
Hydroptilidae	S. Fork	0	5.3	0	7.1	0	8.9	21.3	3.6
hydroptila spp.	K. Bend	5.3	2.1	0	0	0	13.3	20.7	3.4
	Press	0	0	0	0	0	8.9	8.9	1.5
	Osb	0	0	0	0	0	1.3	1.3	0.2
	Total	5.3	9.2	8	7.1	0	33.7	63.3	

Table B3. Con't

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	5.3	0	5.3	0.9
Brachycentridae	S. Fork	0	0	0	0	0	0	0	0
brachycentrus spp.	K. Bend	5.3	4.8	0	0	28	1.8	39.9	6.6
	Press	0	0	0	0	0	0	0	0
	Osb	0	0	0	0	0	0	0	0
	Total	5.3	4.8	0	0	33.3	1.8	45.2	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	0	0	0	0
Rhyacophilidae	S. Fork	0	0	0	0	0	0	0	0
rhyacophila spp.	K. Bend	0	1.8	0	0	0	0	1.8	0.3
	Press	0	0	0	0	0	0	0	0
	Osb	0	0	0	0	0	0	0	0
	Total	0	1.8	0	0	0	0	1.8	

Species	Site	Sept	Oct	Nov	March	April	August	Total Annual	Mean Annual
	M. Fork	0	0	0	0	0	0	0	0
Glossosomatidae	S. Fork	0	0	0	0	0	0	0	0
glossosoma spp.	K. Bend	0	1.8	0	0	0	0	1.8	0.3
	Press	0	0	0	0	0	0	0	0
	Osb	0	0	0	0	0	0	0	0
	Total	0	1.8	0	0	0	0	1.8	

Appendix C

Mean daily temperatures (degree days) in Celsius summed by the month, season and year for the three sample stations on the Flathead River and one site on the South Fork. The three-month total is given to the right of the monthly value.

Table C1. Mean daily temperatures (degree days) in Celsius summed by the month, season and year for three stations on the Flathead River. The three-month total is given to the right of the monthly value.

SOUTH FORK (regulated)						
	WATER YEAR					
MONTH	1979		1980		1981	
October			148.5		155.5	
November			162.5	484	143	452
December			173		153.5	
January			130		144	
February			115.5	378.5	120	390
March			133		126	
April	135		145		127.5	
May	108.5	378.5	160	443.5	138.5	400.5
June	135		138.5		134.5	
July	120		141.5		155.5	
August	124	394	152	436	181	498.5
September	150		142.5		162	
Totals				**1,742**		**1,741**

Columbia Falls (partially regulated)						
	WATER YEAR					
MONTH	1979		1980		1981	
October			188.5		209	
November			141.5	432	129.5	430
December			102		91.5	
January			34.5		74	
February			38.5	153.5	74.5	278
March			80.5		129.5	
April	135		168.5		156.5	
May	186	591	234.5	693.5	218.5	611.5
June	270		291		236.5	
July	356.5		389		371.5	
August	279	950.5	361.5	1,012	466	1,151.5
September	315		261.5		314	
Totals				**2,290.5**		**2,471**

Table C1. (Continued) Mean daily temperatures (degree days) in Celsius summed by the month, season and year for the three stations on the Flathead River. The three-month total is given to the right of the monthly value.

NORTH FORK (unregulated)						
	WATER YEAR					
MONTH	**1979**		**1980**		**1981**	
October	201.5		225	251	217	
November	30	231.5	Nodata		83	310
December	0		26		10	
January	0		5.5		22	
February	0	46.5	2	62	26.5	150.5
March	46.5		54.5		102	
April	135		scattered		149	
May	186	621	data		209.5	607.5
June	300				249	
July	449.5		452.5		410.5	
August	480.5	1,305	422.5	1,202.5	467	1,214
September	375		327.5		345	
Totals		**2,204**		**2,220**		**2,282**

Table C2. Mean daily temperatures (degree days) in Celsius summed by the month, season and year for the three sample stations on the Flathead River and one site on the South Fork. The three-month total is given to the right of the monthly value.

MAINSTEM @ COLUMBIA FALLS (partially regulated)				
	WATER YEAR			
MONTH	1997		1998	
October	257		234.5	
November	105.6	444.6	113.1	451.9
December	82		104.3	
January	70.5		78.5	
February	71.2	229.7	94.5	288.7
March	88		115.7	
April	126.7		183.4	
May	196.1	586.8	258.9	761.2
June	264		318.9	
July	427		476.7	
August	457.7	1,259.8	499.4	1,417.6
September	375.1		441.5	
Totals		**2,520.9**		**2,919.4**

* Middle Fork 1997 **incomplete** (Jun & Sept)

MIDDLE FORK (unregulated)				
	WATER YEAR			
MONTH	1997		1998	
October	213.5		230.7	
November	49.6	278.8	82.9	333.3
December	15.7		19.7	
January	5		7.6	
February	22.5	87.4	54.6	155.1
March	60.2		92.9	
April	120.8		171.3	
May	**79.5**	200.3	246.1	723.1
June	0		305.7	
July	**300.8**		501.3	
August	**387**	687.8	526.5	1,460.6
September	0		432.8	
Totals		**1,254.3**		**2,672.1**

Table C2. (Continued) Mean daily temperatures (degree days) in Celsius summed by the month, season and year for the three sample sites on the Flathead River and one site on the South Fork. The three-month total is given to the right of the monthly value.

SOUTH FORK (regulated)				
	WATER YEAR			
MONTH	**1997**		**1998**	
October	300		219.5	
November	160	564.5	129.5	471.5
December	104.5		122.5	
January	93		108.5	
February	81	267	98	322.5
March	93		**116**	
April	90		**138.5**	
May	114.5	409.5	163.5	613
June	205		**311**	
July	365.5		**432**	
August	468.5	1,225.5	470.5	1,337
September	391.5		434.5	
Totals		**2,466.5**		**2,744**

NORTH FORK (unregulated)				
	WATER YEAR			
MONTH	**1997**		**1998**	
October	262.5		**221.5**	
November	**75.5**	366	62	291
December	**28**		7.5	
January	2		12	
February	37.5	148	68	192.5
March	108.5		112.5	
April	110		182.5	
May	184	567	244.5	723
June	273		296	
July	378		491.5	
August	557	1,338.5	505.5	1,403.5
September	403.5		406.5	
Totals		**2,419.5**		**2,610**